

ORTHOPÆDIC SURGERY

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WITH A FOREWORD BY

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FOREWORD

It is interesting to ponder for a moment on the manner in which the science and the art of surgery have developed, and continue to progress. In early days surgery was a speciality, and during some four centuries its standard was such as to justify the distinction in the best sense of the term. One is apt to forget the significance of the contributions which were made to surgical literature during the period from the twelfth century to the end of the fifteenth. It is true that the results of accident and war, rather than the ravages of disease, supplied the material upon which the surgeon worked, but none the less the progress of knowledge was such that the mediæval surgeons of the Italian School practised and described an antiseptic technique, while the French surgeons of the fourteenth century, and notably Guy de Chauliac, employed a method of anæsthesia which even at this time makes interesting reading. The surgical progress of those days reached its height at the time of the Renaissance, there then followed a period of decline, both in interest and in achievement, and it is significant that during this time surgery ceased to be regarded as a speciality except in the hands of a few. It was practised as a side issue of general work, and even as an adjunct of a non medical activity.

Within the past half century surgery has regained its position as a special branch of medical science, at first as general surgery, the practitioner being prepared to deal with what could be grouped as surgical affections in any region of the body. It was inevitable that, as knowledge increased, the details became so vast, and the calls, both on time and opportunity, so exacting that secondary specialities branched off from the mother science. Certain of these offshoots were obvious and logical developments, and their achievement afforded immense stimulus to the advancement of knowledge, but there has been a possibility that the process of repeated "break aways" might leave the mother science but a shadow, annihilated by the very multiplicity of the family which she bore. In fact, in certain parts of the world it has been more than a possibility, there has been a smultitude of reality, so that it has led one writer to visualize a future in which the general surgeon would know less and less about more and more while the specialist would know more and more about less and less, a process which, if carried to its logical conclusion, would result in the interesting position of the general surgeon knowing nothing about everything, while the specialist would know everything about nothing.

In truth, however, the matter is too serious for jest, and, to those who have tried to visualize the future, the problem has given much anxious thought. It may be that a way out of the difficulty is being demonstrated by those men, who, while practising general surgery, have followed the call of training, of ambition, or, it may be, of interest, and

have adopted for particular attention and study one special branch in the wide field of general surgical work.

Mr Mercer comes into this category. Trained as a general surgeon and practising general surgery, he has been specially attracted by orthopædics, and in the development of that branch of surgery he has laid and is continuing to build upon the sure foundation of a wide and catholic experience. I believe that, if the progress of our art and science is to advance along well balanced lines, it will be by the observance of the policy which Mr Mercer has so successfully adopted.

I daresay Mr Mercer will agree that his interest in orthopædics was first aroused by the experience which he gained in the treatment of fractures while he was Assistant to Mr J W Dowden. During the post war period his work in the Orthopædic Centre at Bangour, and afterwards in the Pensions Department, further stimulated his interest, while his position as Surgeon to the East Fortune Sanatorium affords him valuable and varied experience in the orthopædic problems associated with tuberculosis. Since 1925 Mr Mercer and I have been associated as colleagues on the staff of the Edinburgh Royal Infirmary. As an Assistant Surgeon he has taken special interest in the orthopædic work of the wards, the treatment of fractures is committed to his care, he is responsible for a considerable share of the operative orthopædic work, and in the sphere of teaching he gives a series of orthopædic demonstrations which I know are highly appreciated by both students and graduates. I gather that an elaboration of these lectures and choiques forms the nucleus around which this book has been developed.

Writing a book is a laborious business. Robert Louis Stevenson said of Dr John Brown, the author of *Rab and His Friends*,

He stapped yer pen into the ink
And there was Rab

I doubt if Stevenson is accurate. The classic of Minto House was the outcome of observation, philosophy and thought. I know that when Mr Mercer 'stapped his pen into the ink' it was to commit to paper the considered opinions of many years of practical experience.

He has asked me to write this foreword, and it has been a great pleasure and a privilege to comply with his request. I have written it on general lines with perhaps a tincture of history. I have avoided any comments on the plan and contents of the volume, for such is not within the sphere of the writer of a foreword but, from what I have read in manuscript, I believe that Mr Mercer has contributed a most readable and practical treatise on the subject of orthopædics. I know how great has been the enthusiasm with which he has applied himself to the difficult task, I have some knowledge of the detail and the care which he has bestowed upon every page and if these are the hall marks of a successful publication, this volume assuredly deserves success.

JOHN FRASER

PREFACE TO THIRD EDITION

One's existence has been so altered with the last few years of horror and tragedy that the production of a third edition was faced with a certain trepidation. Most of my younger friends who helped so generously before are now on another continent leaving irreparable gaps in both my professional and personal life. However in spite of these circumstances and the inevitable increase of work through the years of war the attempt has been made but it is hoped that it will not be too critically judged.

Every chapter has been carefully gone over and new ideas have been incorporated both from personal experience and from the literature of the period. Many operations that I consider are no longer useful have been deleted and where prudent a choice of procedure is indicated.

Amongst the sections which have been to a great extent re-written are those on Circulatory Disturbances, Affections of the Back, Knee, Shoulder and Foot and Infections of the Hand. In all of these an attempt has been made to bring them up to date and this has unfortunately resulted in more pages and many new illustrations.

Acknowledgement has again been made to other than personal sources of information and if in any instance this has been omitted it will be generously recorded in the next edition. I am particularly grateful to H. A. Brittain for his ingenious operations on joints and to Mons. Iselin for his monograph on infections of the hand both of whose ideas have been most helpful to me in my practice and whose teachings I have incorporated in this edition.

I am proud to acknowledge with gratitude the loyalty and service I have received in the re-writing of some sections of the book from Mr. Ian Smillie and Mr. Andrew Wilkinson. Mr. David Smith (photos) and Mr. R. M. Matthew (drawings) have also given me valuable assistance. Miss Oliver, my secretary, has compiled the index, listed the references, read the proofs and done all the hard routine uninteresting work and so has eased my labours considerably. To Sir John Fraser under whose mantle I have sheltered for 22 years I owe much. He has been ever an inspiration, an encouragement and a help and I am grateful. And to one other there is of course an unredeemable debt.

My thanks are also due and are gladly given to the publishers for their unfailing courtesy and helpfulness.

W. M.

PREFACE TO FIRST EDITION

This volume is a response to many requests that permanent form should be given to the series of lectures and clinics on orthopædic subjects which I have given under the direction of Professor Fraser during the last few years. These requests have come from post graduates reading for the Fellowship in Surgery, and from undergraduates. Their needs, therefore, have received special consideration.

Father Stanton remarked once that he did not want to publish his sermons as people would then recognize how much he owed to Spurgeon. How much I owe to the Spurgeons of my profession will not be difficult to gauge from this work. It would be a hard task for me to redeem these obligations to the goodly company who have been, and are, my surgical guides, and towards whom through their writings and from personal contact, I cherish that peculiar affection which men feel for their own particular surgical Gamaliels.

It may occasion surprise that a general surgeon should have the temerity to write a book on a special subject, but the Edinburgh Medical School maintains the tradition that a surgical speciality is only a branch of general surgery, and that to become a good specialist one must first be a good general surgeon. In the compilation of a book such as this it has seemed to me to be a considerable advantage to look upon the subject from the point of view of a general surgeon and I hope that that view point is reflected in these pages.

The reader may be surprised also at the appearance of yet another book on this subject. The time, however, appears to be ripe for a volume of moderate size containing the essentials of the old and a summary of the new. An attempt has therefore, been made to give a comprehensive survey of each subject, including the latest work, and, on occasion, the expression of personal opinion. In a book of limited size it is impossible to consider the details of conflicting theories. Where there is considerable divergence of opinion the aim has been to give prominence to the theory which appears at the moment to be the most generally accepted, and to deal more briefly with others which are still in the realms of controversy.

Again, owing to the limits of space, no attempt has been made to give a comprehensive bibliography, but where a more detailed study of the literature seemed desirable references have been given to authoritative articles on the various subjects. An endeavour has been made to describe the technique of operations with sufficient detail to enable the young surgeon to perform them with some confidence.

The pleasantest portion of my task is to acknowledge the kindness and help which I have received from so many friends. My first debt is due to my old chief, John Wheeler Dowden, who, seventeen years ago, imbued me with an enthusiasm for orthopædic surgery that has

never left me, and who ever since has been my valued friend and counsellor

I owe a particular debt of gratitude to Professor John Fraser, who, from the outset, has given me most useful help, inspiring suggestions and a wealth of advice. He has been not only a most kindly monitor, but also a most sympathetic friend, and I value more than I can say the encouragement he has given me. Much of the work on which the book is based has been carried out in the Department of Clinical Surgery of the University of Edinburgh under his charge.

Most of the proof reading has been done by my good friend, John Bruce, who has in addition supplied the cold and reasoned criticism that is so helpful in the editing of a book. Much of the ease in reading and methods of tabulation are due to him.

There are many others to whom I am very grateful. I would specially refer to Dr H. Torrance Thomson and to Colonel F. R. Hill, C.B.E. for assistance in proof reading to Dr J. C. Tansh, Mr Allan Armstrong and the successive Radiologists to the Royal Infirmary of Edinburgh for X rays to Mr D. B. Smith Assistant in the Laboratory of the University Department of Clinical Surgery, for his great assistance in the photographic work and to Dr E. B. Jamieson, for hints on editorial arrangement. To Dr Charles Cameron, of East Fortune Sanatorium I owe a great debt for his valuable suggestions for the chapters on Tuberculosis and for many of the excellent illustrations in these chapters. My secretary, Miss Oliver has been most helpful and enthusiastic in carrying out the clerical work, and has been untiring in generally supervising the important proof stages.

The line drawings have been done by my wife. She knows how much her work and her encouragement mean to me.

In the bibliography I have, I trust, acknowledged the various sources of information to which I am indebted. If through inadvertence, any have been omitted I apologize and hope that I may have in the future an opportunity of making due acknowledgement.

I wish to acknowledge my indebtedness to Professor John Fraser for permission to reproduce certain diagrams from his book, *Surgery of Childhood* and to Mr A. J. Walton, Mr H. A. T. Fairbank, Mr Robert Milne and Mr E. Rock Carling for permission to reproduce diagrams from *Surgical Diagnosis*, edited by Mr A. J. Walton.

Lastly, I have to express my grateful appreciation of the courtesy of the publishers and the care and attention given to the work by them.

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ORTHOPÆDIC SURGERY

CHAPTER I

INTRODUCTION

Sir Arthur Keith has aptly defined the scope of orthopædic surgery To effect the repair of the mechanical framework of the human body by all operations and appliances which may have that aim in view

The term orthopædy adapted from the two Greek words *ορθος* meaning straight upright or free from deformity and *παι, παιδος* a child was originally used by Nicholas Andry whose work *L Orthopédie ou l Art de prevenir et de corriger dans les enfants les déformités du corps* was published in 1757 and though orthopædic surgery has long since outgrown its original definition no more descriptive or more accurate term has been invented for it so far

Modern orthopædics is concerned with the study of the form and function of the human frame its attack is directed against those affections that deform the architecture or arrest the balanced mechanism of man's body and injuries of bones muscles nerves and soft structures which result in loss of form or function are thus its legitimate objective

Andry originally taught orthopædics as a branch of preventive medicine rather than as an off shoot of surgery and the various methods he described of preventing and correcting bodily deformities in children were in his own words within the reach of fathers mothers nurses and others entrusted with the bringing up of children Andry's words need not be passed over lightly for they have a moral even for our enlightened days prevention is always better than cure and if the principles and practice of preventive orthopædics were more liberally applied to-day many of the severer degrees of flat foot scoliosis and similar deformities would disappear But the timely institution of preventive measures demands the early recognition of incipient loss of form or function—an ideal to be attained only by periodical inspection of the young by one trained in orthopædic surgery

The solution of the problems of an orthopædic case depends on a clear understanding of the pathological nature of each lesion and success in treatment on a scrupulous attention to minute detail Orthopædic work is thus exacting for the surgeon must supervise person

ally each detail of treatment, and consequently devote more time to each individual patient than in any other branch of clinical work. The stimulus of success, however, will prove an ample reward, and the lightening of the burden of cripples and the deformed—not only the physical and visible burden, but the subtler and less evident mental one—may well be considered the pinnacle of surgical achievement. Those who escape contact with the deformed do not appreciate the keen mental anguish which they suffer—a mental anguish that led Gloucester, when bewailing his fate in his sad monologue in *Richard III*, to exclaim

“Cheated of feature by dissembling nature
Deformed unfinished, sent before my time
Into this breathing world scarce half made up
And that so lamely and unfashionable,
That dogs bark at me as I halt by them.”

Even if no other word is uttered, it is worth while to hear your patient say, ‘You have made me walk.’

The Scope of Orthopædic Surgery Orthopædics as a specialized branch of surgery, though it has been growing progressively since the days of its great pioneers, has achieved its present prominence largely as a result of two closely related factors, the casualties of the last war, and the accidents incidental to the present mechanical age have, together, shown the need of better treatment for the injured, and aroused surgeons everywhere to greater effort.

Orthopædic affections fall into one or other of six groups

- 1 Congenital anomalies
- 2 Affections of joints
- 3 Affections of bones
- 4 Affections of muscles, tendons and other soft tissues
- 5 Affections of the nervous system
- 6 Static deformities

While many of the lesions have a definite pathological basis it is being realized more and more that a large number of orthopædic disorders are the end results of postural or static anomalies induced by habit, rather than by definite pathological change. In this connection Goldthwaite has pointed out that only by using the body correctly can the best be got out of it, and that should the elaborate mechanism which controls and maintains the body in its upright position fail, the body processes are upset and the stage is set for many obscure and distressing maladies. The role of the orthopædic surgeon in such a case is to correct body posture. He became convinced, furthermore, that to treat any of the sequelæ of faulty posture was futile without first correcting the posture itself by ensuring the correct use of the body and by modifying faulty mechanics. Many of the following pages are occupied with this aspect of the orthopædic problem, its

intrinsic importance is great, and, farther, it has an important lesson to teach—that, from the orthopædic standpoint, the body must be viewed as a whole, even though the actual complaint is a local one

The Examination of an Orthopædic Case

No part of orthopædic training is more important than the acquisition of a systematized method of examination. It cannot be too strongly urged that a true knowledge of disease, which forms the basis of successful diagnosis and treatment, can be founded only on the careful and accurate study of individual cases. Scientific and orderly investigation is as essential in orthopædic conditions as in any obscure internal malady.

I. The History.

At the first consultation, it is necessary to elicit a complete and accurate history of the patient's complaint, the mode of its onset, and the order in which the symptoms were first observed.

(a) *The Complaint* The chief complaint may suggest to some extent the nature of the affection, while it always focuses attention on some definite part of the body.

(b) *The Manner of Onset* The illness may begin suddenly, or it may be gradual and insidious in its development. Apart from trauma, the most likely cause of sudden derangement is acute infection. When the onset is insidious, it may be due to a low grade inflammation, granuloma or tumour, a slow degenerative process, or a postural anomaly.

(c) *Pain* The type, character, and distribution of the pain are important, since they all assist in reaching a diagnosis.

(d) *The Question of Preceding Injury* There is a distinct tendency to ascribe all orthopædic symptoms and errors to some injury, often sustained at a date considerably remote. An attempt should always be made to ascertain the exact details of any alleged trauma, and to establish its exact relation to the actual lesion as this may have important medico-legal bearings. Such an inquiry should be directed towards discovering whether the symptoms arose at the time of the injury, existed previously, or only appeared subsequently. An example will make the importance of such an investigation obvious. The author was recently consulted by a lady who suffered from a dislocation of the hip which she ascribed to a recent railway accident. After careful clinical and radiological examination, it was evident that the condition was a congenital dislocation. A good practical rule is to ascertain whether the patient was able to leave the scene of the accident unaided, or whether he required immediate assistance.

II. Clinical Features ; Symptoms and Signs.

The clinical features may be objective or subjective. The objective features, or signs, are those—such as deformity, errors in attitude or gait, and limitation of movement—which are obvious to the examiner. The subjective symptoms are those of which the patient complains, but of which the surgeon has no definite positive evidence. Considerable tact

and discrimination are often required to disentangle the truth from the complaints of patients who are neurotic, hysterical, or malingering

III. The Examination of the Case

The examination of an orthopedic case must include not only the physical condition of the patient, but any laboratory tests, and special investigations suggested by the clinical findings. Unless the complaint is a minor one, limited to one extremity, it is wise to make the examination with the patient stripped of all clothing, save, perhaps, bathing drawers, and in the case of a female patient, some covering for the breasts. The examination may be conveniently considered in two parts

1 The examination of the body as a whole

2 The examination of the affected member or part

(a) *The Examination of the Body as a Whole* The attitude and carriage of the body are observed when the patient stands and walks and the manner in which the weight is borne on the soles of the feet, and the relation of the feet to the legs, should be noted. The relation of the hips to the pelvis, and of the shoulders to the chest, is observed, and the contour of the spine, chest and abdomen investigated. The inspection of the body is carried out from behind as well as from the front and laterally. Particular attention is paid to the spinal column and the situation of the spinous processes may be marked with a skin pencil and also the lower angles of the scapulae. The position of the pelvis in the erect posture is often important, and differs in the two sexes. The female pelvis is lighter in construction than the male, its height and the expansion of its iliac crests are less. The position of the pelvis depends upon the iliofemoral ligaments, when these are short it lies more obliquely, as the pelvis is pulled forwards, when they are long, a greater degree of extension is possible at the hip joints, and the pelvis is tilted backwards and loses a good deal of its obliquity. In men, the pelvic obliquity is less than in women and the anterior superior spine lies on a plane slightly posterior to that of the symphysis pubis, the curvature of the lumbar spine is thus less than in the female, in whom lumbar lordosis is often marked.

(b) *The Examination of the Affected Member or Part* The thorough examination of the affected part demands a considerable knowledge of the anatomy of its joints, nerves, and muscles. It should also follow a routine plan and must never be haphazard or unsystematic. The various details observed and elicited should be carefully recorded.

METHOD OF EXAMINATION

(a) *Inspection* The attitude in which the part is held, its general appearance and colour, and the presence of deformity, are noted. In the case of a limb a comparison should always be made between the affected and the presumably healthy side.

(b) *Palpation* Handling of the affected part will elicit such objective phenomena as tenderness, fluctuation, elevation of local tem-

perature induration, or gross alteration in shape. Friction within a joint may be discovered by combining palpation with passive movement.

(c) **Passive Motion** Valuable information may be obtained by carrying out the movements of which the part is normally capable and by comparing this range with that on the normal side. The amount and quality of the movements are assessed and the presence or absence of pain determined.

Limited joint movement may be due to some bony block, to adhesions between the joint surfaces or to reflex spasm of the related muscles as in early cases of tuberculosis. During movement there may be a grating or cracking sensation comparable to that produced between the ends of a broken bone. Such crepitation is characteristic of osteoarthritis.

Abnormal joint movement may take the form either of excessive mobility or of false mobility. In the former the normal range of movement is exaggerated in every direction, in the latter, the joint moves in a new or abnormal direction.

(d) **Active Motion**—This represents the degree to which the patient can without assistance move the affected part. It is usually considerably less than the amount of passive motion, the limitation being due to a similar cause aggravated by a greater degree of spasm or weakness or paralysis of the associated muscle groups.

In certain cases it may be advisable to record accurate observations of the range of active mobility. This is usually done by employing an apparatus such as an arthrometer. It is often instructive to compare the readings on subsequent occasions as in this way an index of improvement is provided. The instrument is a simple one consisting essentially of two metal strips joined by a hinge. Opposite the joint there is a protractor graduated in degrees. The joint is controlled by a thumb screw, so that after the angle or arc of movement has been estimated the arthrometer can be fixed until the reading is made. Other methods may be employed but it is important always to adopt the same technique to eliminate possible sources of error.

In making the record the degree of passive and active movement at any joint may be conveniently denoted by symbols. e.g. N 4 may be used to represent the normal N 3 for 75 per cent of normal N 2 for 50 per cent of normal and so on.

(e) **Mensuration** Careful comparison of the measurements of the affected part with those of the opposite healthy side will often demonstrate atrophy or hypertrophy.

The length of the limbs is measured in order to assess any inequality that may be present. In the leg the measurement is taken from the anterior superior spine to the level of the knee joint or to the medial malleolus. Certain lines may be drawn in the neighbourhood of the hip joint which are of value in discovering the site of any shortening in that region.

Nelson's line extends from the anterior superior spine to the tuberosity of the ischium. Normally it passes through the tip of the

greater trochanter but in pathological conditions of the head or neck of the femur the trochanter is displaced upwards and lies above Nelaton's line.

Bryant's triangle is formed by the perpendicular dropped from the anterior superior spine when the patient is lying on his back. The base is the line extending from the tip of the trochanter to this perpendicular while the hypotenuse is represented by the line joining the trochanter and the anterior superior spine. Here again in pathological conditions of the femoral neck or head the base of the triangle is shortened whereas in fractures of the shaft or shortening situated in parts other than in the base and neck the normal relations are maintained.

Schoemaker's line is valuable in that its demonstration requires no movement of the patient. It is drawn from the tip of the great trochanter through the anterior superior spine and prolonged towards the mid line. Where the trochanter is displaced upwards the continuation of the line meets the middle line of the body below the umbilicus whereas in the normal case the mid line is reached above the umbilicus.

(f) **Auscultation** This may be of value particularly in the neighbourhood of joints for locating crepitation snaps and friction rubs. As a rule however these can be detected without the aid of the stethoscope.

(g) **Neurological Examination** Routine neurological examination is unnecessary but sometimes when lesions of the nervous system are suspected in adult patients it may be of value to test the reflexes and the cutaneous sensation. If necessary a systematic neurological investigation can then be carried out including the withdrawal and the examination of the cerebro spinal fluid. Lesions of the peripheral nerves form an important class of orthopædic error examination in such cases must follow a systematic plan consideration of which is discussed later.

(h) **Aspiration** In cases of joint effusion and in cystic swellings in other areas aspiration and examination of the joint or cyst contents may yield valuable information. A 10 c.c. syringe should be used with a fairly long needle of wide gauge. The needle is inserted through the skin some way from the swelling in order that the skin puncture be situated as far as possible from the breach in the cyst or joint capsule, in this way risk of subsequent infection is diminished.

The contents should be submitted to microscopic and chemical examination and an attempt made to culture any organism present. A Wassermann test is carried out when necessary.

In some cases—particularly in tuberculosis—it may be advisable or even essential for diagnostic purposes to inoculate a guinea pig with the aspirated material.

(i) **Radioiological Examination** Examination by X rays is necessary to complete the diagnosis in the majority of orthopædic conditions. When the affection is unilateral it is usually advantageous to secure at

the same time a radiograph of the normal side as by this means the slightest and earliest evidences of disease may be recognized. Care must be taken however to ensure that the two sides are in a strictly similar position at the time of exposure. In parts such as the pelvis hip joint shoulder and skull a stereoscopic view is invaluable.

In a proportion of cases the radiogram will be negative. Even after definite bone inflammation a considerable time—even up to six weeks—may elapse before reliable X ray evidence of change appears. In the case of bone diseases therefore it is often necessary to make repeated exposures of the affected part before a conclusion can be reached regarding the presence or absence of a real pathological process.

The X ray film may not only establish the diagnosis it may assist the surgeon to formulate a prognosis while examination at repeated intervals especially in tuberculous bone or joint lesions enables him to assess the progress. It seems unnecessary to point out that the quality of the film must be high if important decisions are to be made on its evidence. A radiogram of bones to be of any value must show up clearly the internal architecture.

The pathological changes revealed by radiograms of bone are of three types.

(a) *Atrophy* or wasting of the osseous structure demonstrated by a decrease in density and loss of trabeculation. It is due to loss of lime salts and may be local or general.

(b) *Hypertrophy* or increased density of bone structure. This also may be widespread throughout the bone or localized to a small area.

(c) *True destruction* of bone. The area destroyed may be an entire segment of bone or a localized superficial erosion and occasionally a small area of destruction is found in the interior of the bone. The various findings have all a definite significance which will be referred to later. In many cases too all these conditions co exist within the same bone.

The radiographic examination of joints should always include two views at different angles particularly if the joint is fixed in an abnormal position. It has been shown by Campbell that when the knee joint is fixed in flexion and the routine antero posterior view of the joint is impracticable a satisfactory anterior view may often be secured by fixing the film to a cylinder which is placed in the popliteal space when the exposure is made.

(j) *Pathological Examination*. The last method which may have to be resorted to is biopsy in which a portion of tissue is removed for microscopic and pathological examination. This method is particularly applicable to cases of tumours both of bone and other tissues and joint infections of doubtful origin. When tuberculosis is suspected the tissue removed may be emulsified and injected into a guinea pig. Such injections are usually made into the peritoneal cavity of the animal and six weeks later the lymphatic glands are examined for the bacillus of tuberculosis or for evidence of its presence.

Plaster-of-Paris Technique

An orthopædic surgeon must know how to apply a plaster case, this knowledge is as essential for an orthopædist as is a knowledge of asepsis for any general surgeon. Calot has said very truly that you can judge of the skill of the orthopædic surgeon by the apparatus he uses. "Show me your plaster apparatus and I will tell you what kind of orthopædist you are."

Plaster of Paris is more frequently used than any other material for retentive apparatus in orthopædics and by its use the different parts of the body may be secured in any position desired. Its popularity is based on two considerations: firstly, it is necessary to maintain a limb in the desired position only for the few minutes required for setting, and then the position is secured permanently; secondly, because of its adaptability it gives results superior to those of all the splints of metal or of wood that have ever been evolved.

The equipment necessary for the application of plaster is as follows:

(i) *Crinoline* a gauze stiffened with starch not size. A special crinoline or book muslin is used which has a mesh of 32 threads to the inch each way. It is cut in the desired widths—4, 6, and 8 inches being the most useful.

(ii) *Plaster of Paris* or calcium sulphate—a white powder made from gypsum and known as superfine plaster. The stone is crushed and pulverized, after which it is subjected to intense heat so that the water of crystallization is driven off. When mixed with water it undergoes a re-crystallizing process which is commonly called "setting."

(iii) *Stockinet* or underwear material bought in various widths.

(iv) *Wool bandages*

(i) *White felt*, preferably of the piano makers' type. Saddlers felt, though much cheaper is coarser and not so comfortable for the patient. The thickness of the felt varies to about three quarters of an inch. It can easily be split into thinner pieces.

The felt wool bandages and stockinet are sterilized in the autoclave to eliminate risk of tetanus spores infecting a plaster sore.

(vi) *White adhesive felt* a quarter of an inch thick backed with zinc oxide.

(vii) *Aluminium strips*. These should be about 2 feet long roughened perforated and flexible.

(viii) *Cramer wire*, $3\frac{3}{4}$ inches by 24 inches.

(ix) Some *wood lathes* one inch square, of various lengths for reinforcing plaster and for buttresses.

(x) An *orthopædic or fracture table* of the "Shropshire Horse" type.

(xi) An *Abbott frame*.

(xii) An *upright suspension frame* with spare apparatus attached.

The instruments required are Stille's plaster cutters of various sizes, a saw, a hacksaw, a plaster opener of the glove stretcher type, plaster

of plaster It is left at the bottom till all bubbling has ceased When lifted clear of the water the bandage is squeezed and twisted, with a hand at each end to prevent escape of plaster This simply drives out excess of water and the bandage is still very wet This is done by an assistant, who then finds the end of the bandage and unfolds it for a distance of 2 to 3 inches, thereafter handing it to the surgeon

Once the bandage is applied to a part it neither stretches nor contracts but is rigid, but before it is dry it is pliable Between these two states the limb is maintained carefully in the required position. The slightest movement during the setting is apt to form ridges inside and interfere seriously with the later comfort of the patient Should it be found necessary, therefore, to alter the position of the patient during the setting the plaster has to be removed and a new one applied.

Two methods are described for the application of the roller plaster bandage to ensure that it lies evenly and also to permit change of direction—the “loop” by which a one to two inch loop of bandage is thrown back and the run of the bandage re directed, and the “draw” where one edge of the bandage is drawn back a little with the free hand while the run is directed These methods, of course, are of most importance in the inner layers to prevent ridges or unevenness Where a prominence like the anterior superior spine is being clothed, a loop is applied as each turn covers the spine and at the same time the plaster is well rubbed in and moulded to exaggerate if anything the hollows round the bone Pressure on the bone is usually thus prevented

After the primary thin tube of plaster is on and fitting like a glove the outer structure is put on with the sole purpose of adding strength where it is needed Many parts may be left unstrengthened—e.g. dorsum of the foot, front of the elbow, and the axilla This second stage, as it may be called, may be done by bandage or added to by plaques or slabs of plaster of Paris

Plaster Slabs The usual slab is made from a Cellon bandage by holding the end in the left hand and allowing the bandage, supported by the right hand, to unroll downwards by its own weight until twice the requisite length is got This length is then folded up on itself and the left hand holding the end now has added to it a fold of bandage, usually about 5 feet from the end, so producing a length of $2\frac{1}{2}$ feet, the size of slab ordinarily in use Where home made bandages are used the slab is made on a smooth board or bottom of a sink, from the bandage already soaked Small slabs are used for the forearm and hand as in a Colles's fracture, while larger sizes are used for reinforcing weak spots in big cases, as in the “groin” of a hip spica, and is then often gathered into a round rope to form a buttress A similar strengthening effect is got by the incorporation of aluminium or other metal strips in the plaster over the weak parts These strips should be thin, fairly wide and made of rough metal with perforations so that they do not come adrift in the plaster When slabs are used on a flat surface they are more easily applied by two workers each taking an end and

pulling so as to flatten out creases, and thereafter applying flat to the desired area

Polishing Before the plaster is dry a nice even polish should be applied. A layer of well soaked bandage is evenly applied all round in an even direction and, where there is apparently not a surplus of plaster in the bandage, some plaster cream is put on with a wet hand. The polish is put on simply with the freshly wet hand which is frequently dipped alternately in water and plaster cream.

Occasionally, in a body case, a piece of bandage material called a "scratcher" is inserted. It projects from both ends of the case and is inserted under the protective stocknet. By using a see saw pull through motion the skin can be kept clean or scratched as the case may be. The "scratcher" can be changed by tying a new one to one end of the old one and pulling it through.

After the plaster bandages have been applied and partially set, the edges are trimmed in order to prevent any chafing of the skin and any undue pressure on parts by flexion of joints, such as the lower part of the front of a plaster jacket on which the groins may impinge in sitting. Frequently a portion of a plaster jacket about the size of a dinner plate is removed from the epigastric region, the object of which is to facilitate respiration and permit of abdominal expansion. After trimming, the case is finished by the application of plaster cream, made by mixing plaster powder with lukewarm water until a creamy consistence is obtained. This is rubbed in all over the plaster and, when partially dry, is polished with a little water.

Drying Though the plaster case is dry and set in a few minutes it goes on exuding water for more than 24 hours. During this period the plaster should be covered with a cage, preferably a radiant heat cage. If it is covered with bedclothes the plaster will be softened and spoiled.

In children, when there is a likelihood of the case being soiled, it is helpful to paint the case with either shellac or varnish.

The toes or the fingers should always be left exposed, in order to judge of the circulation in the limb. An exception may be made, however, in the case of the fifth toe which is liable to pressure if the plaster is trimmed to its base.

The edges of the case may be protected against soiling by means of oil silk, oil cloth, or gutta percha. A permanent binding on the edges of the cast may be made with an Ajax shoe stapler.

A good plaster case should be as light in weight as possible, the inside should be smooth, and it should fit snugly without constriction so that there is no friction on the skin. The toes and fingers should be visible. Where there is any question of circulatory interference as evidenced by swelling, or discoloration, the case should be split, and the edges of the split spread. The nurse should observe the skin temperature of the fingers and toes frequently, to ensure that they are not getting cold from compression or constriction.

Instead of using an epigastric window to secure room for expansion a dinner pad of felt may be applied temporarily and removed when the plaster has set

In carrying a patient to whom plaster has recently been applied care must be taken to hold the limbs in such a manner as to obviate movement especially such as tends to call into play the articulations fixed by the apparatus If the plastered leg of a hip plaster is lifted off the table it will be seen how the edge of the spica presses into the ribs since the leg is forced out of alignment with the chest

The Nursing of Patients in Plaster of Paris On return to bed a cage preferably a radiant heat one is put over the case to quicken the complete dehydration of the plaster for though the setting only takes 8 minutes or so the drying requires the best part of two days and during that time movement must be prevented as the plaster is liable to break so long as the least moisture remains The nurse is warned that the case must never be lifted by the leg since it may easily be broken at the groin One of the most important points in nursing the case lies in the careful arrangement of pillows to support the plaster If the shoulder and head rest on pillows the upper anterior edge of the case cuts into the chest The obvious cure is to remove the head pillows and so straighten out the thoracic spine The heel if resting on a pillow presses up and gives the patient heel pressure and so as a rule a few pillows under the limb with nothing under the heel is all that is required

Where it is necessary to strengthen a crack the debris of the plaster bordering on the crack is removed The surface is then roughened with a knife moistened and smeared with thin plaster cream Squares of crinoline impregnated with plaster are then quickly applied before the cream has had time to set Care should be taken to avoid too much reinforcement as this may preclude incorporation with the old plaster

The Creamed Fabric Method Trueta used this method extensively in the Spanish War probably because of shortage of materials though the method has certain advantages Trueta used thick soft flannelette but in place of this now unobtainable standard plaster muslin in large pieces is used It is marked with its proper outline and then cut out rather bigger than wanted as it shrinks about 10 per cent For a wrist about six and for a leg eight layers of muslin are suggested A plaster cream is made of for the leg 2 pints of water and 4 lbs of powder An even cream is made and the fabric passed slowly through it until fully soaked Before the plaster sets it is moulded to the surface and a thin layer of cream is spread evenly over it Some turns of bandage are applied to keep it in place

Cellona is now made in large sheets so that the above method can be carried out more easily more accurately and with much less trouble The sheets of plaster are accompanied by shapes so that all parts of the body may be easily clothed in plaster with a high degree of accuracy and with a good comfortable fit

Skin-Tight Plasters On the whole skin fitting or unpadded plasters are the most satisfactory and effective with perhaps the addition of padding at selected points. The intimate and accurate fitting supports and immobilises all parts to a higher degree than does a padded case. All bony prominences such as the sacrum iliac spines and internal epicondyles of the humerus are carefully padded with felt. Skin tight plasters certainly require greater care in application and must be watched for some time afterwards in case œdema supervenes and produces circulatory obstruction. It is doubtful whether such a plaster is wise after an operation on the part since the inevitable œdema may make the plaster case very tight. A wise precaution is to split the plaster in its whole length after its application and bind on with a wet cotton bandage. Should much œdema be produced the cotton bandage is cut and the plaster gives enough to relieve any circulatory obstruction that may be present.

Bridged Plasters It is often necessary to leave areas of a limb uncovered and free from plaster so that wounds may be dressed and yet have the limb adequately immobilised. In such cases proximal and distal plaster sections may be connected by bridges or ropes of plaster either alone or reinforced with aluminium or other metal inside the plaster. Where the uncovered areas are smaller it is enough to cover with a thin layer of plaster mark out a window on it, and then reinforce the edges of the future window with buttresses of plaster before cutting out the window. The windows are cut out with a sharp scalpel or plaster knife right down to the dressing underneath for in a window area the skin is always protected.

Special Plasters

(1) *Sectional Method of Application* A valuable method of applying a plaster case where a limb or other part has to be held in position during its application is the sectional method. It may be used after bone grafts to the humerus after reduction of a compression fracture of the spine or in leg fractures particularly when changing the first plaster. When the part to be encased is suitably dressed and padded the whole of the front and lateral aspects are plastered usually by slabs but it may be by roller bandages taken across the body or limb reversed and back to the same side. The case extends far enough round the lateral aspect to get a grip of the part so that when the plaster is dry the patient may be turned round on to his face and yet the part be kept adequately immobilized. The back is then carefully padded and the edges of the plaster trimmed and the gap between the plaster edges filled in with further slabs. When the two thirds front and the one third back pieces are firmly joined a few turns of a roller plaster bandage are applied. This is not absolutely necessary, and in any case is usually delayed till the plaster is dry and the patient out of any anæsthetic that may have been used. It is obvious that this is a useful method where the condition of the patient or his position will not permit of

the easy application of round and round bandages, and also where a plaster table is not available. There is no doubt that a much better fitting of the plaster is ensured by this method.

(2) *Arm abduction plasters* are put up with the shoulder in the position of optimum function (see p 371). It is questionable whether the plaster should extend down to the iliac crests. It is often more comfortable and equally efficient if it stops short an inch or two above the crest. The brachio thoracic angle may be reinforced with a metal strut in the plaster or a buttress from the elbow region to the body plaster. The hand should be maintained in the dorsiflexed position by a short extension of the plaster into the palm, stopping short of the metacarpal heads and so allowing free movement at the metacarpophalangeal joints. This plaster may be conveniently applied by the sectional method. On turning, the arm piece hangs on the edge of the table.

(3) *Hip Spica*. This plaster is usually applied on a fracture table—Hawley or Shropshire Horse. Care must be taken to protect the bony prominences—sacrum, iliac spines and lower ribs. When complete on the table the patient in his case is turned on his face on to a trolley, the back carefully examined, and an area cut out over the anal region to ensure clean nursing. The felt covering round the lower ribs and the sacral area is folded back over the outside of the plaster case and held in position with a further plaster bandage or slab. This ensures a smooth felt covered edge to the case.

(4) *Lower Limb*. The fitting of the plaster to the foot is most important. The ankle is held out at a right angle and a felt shoe is fitted to protect the heel and malleoli. The plaster is carried beyond the ends of the toes to protect them from the weight of the bedclothes, and so act as a bed cage. The plaster sole should be moulded so that there is no undue upward pressure on the first and fifth metatarsals, tending to undo the normal anterior arch, or at any rate, the normal downward concavity of this region. The toes should not be prevented from flexion by too much "cock up" of the terminal part of the plaster since this tends to produce an atrophy of the small muscles of the forefoot.

The Difficulties of Plaster Treatment. The chief sources of trouble are—

- (a) Constriction from too tight application of the case
- (b) Pressure from the edges
- (c) Moisture from the patient's excretions

Circulatory Troubles. A plaster produces pressure troubles more from swelling of the indwelling limb than from its own intrinsic constrictive effect. Pressure sores are more commonly produced by friction than simple pressure. The most serious danger of compression of the limb is the effect on the circulation. Complete abolition of this, of course, produces gangrene. Incomplete compression may cause ischaemic

contracture or disturb the sympathetic control. It is therefore of vital importance that undue compression should never occur and if it does be immediately relieved. Whenever a plaster is applied after an operation the case should be split vertically from end to end and then bandaged with a wet cotton bandage. The limb in every case should be elevated as this obviates undue oedema. A careful watch is kept on the limb during the first day or two and any signs of constriction noted in swelling of the toes inability to move them loss of circulation as noted in the peripheral vessels loss of sensation or heat and/or undue pain. Unless the digits are rosy warm and sensitive and can be moved voluntarily the patient cannot be left alone with safety. The compression should be relieved by easing the plaster—either cutting the cotton bandage and easing the plaster or splitting the plaster end to end if this has not already been done. Where circular dressings or bandages have been applied underneath the plaster it is of course essential to divide these also down to the skin as they are equally potential factors in producing compression.

Plaster Sores Some may be due to pressure as described above but they are more often due to friction in a loose plaster case. Where the plaster is a big one and the condition permits it is a good thing to turn the patient for an hour or so night and morning on to his face. Besides relieving him of pressure on his back it allows the latter to be cleaned and treated with boracic powder and spirit. It is also of benefit in helping urinary drainage from the kidney pelves where otherwise the urine tends to stagnate and become infected and it may produce calculi.

Sores often give little warning and that for a brief period at the beginning since they so easily pass into the stage of skin necrosis when the sensitive nerve endings are deadened. The early signs are local pain and general restlessness and these should be looked for noted and reported to the surgeon by the nurse in charge. When the necrosis deepens to the underlying tissues pain comes on again and by this time the characteristic musty odour of pus may be detected. Such symptoms and signs necessitate further and closer investigation by removal of the plaster and its re application.

Frequently the patient may complain of pressure of the edges of the cast. When pain is complained of in either the great or the small toes a longitudinal cut should be made on the dorsal and plantar aspects of the plaster over the affected toe 2 to 3 centimetres in length and the section of plaster thereafter eased outwards so giving the toe more room. It is unwise to split the plaster transversely since this merely produces an area of pressure a little higher up.

An edging of oiled silk or rubber mackintosh protects against soiling. The bed pan should be carefully adjusted so that the flesh of the buttocks will press on the edge of the pan. If the edge of the case rests on the pan moisture will follow the buttocks up under the cast.

Pressure from the edges of a case is oft increased or increased by the

patient's position. When the front of a hip spica presses on the epigastrium or costal margin, the insertion of a pillow under the lumbar curve frequently gives the patient great comfort. Complaint of pressure on the heel is treated immediately by removal of a section of plaster over the affected area. The plaster frequently becomes twisted and pain is referred from above. Where pressure is to be relieved splitting the case is always preferable to making a window. When a hole is cut in a case the tissues may bulge through the opening and produce pressure or deformity.

It is a good practice to smell the case occasionally with a view to the detection of any odour, a musty smell frequently indicates pus or necrosis.

The Removal of a Plaster Case. Many instruments have been devised for the removal of plaster cases, but the best, in the author's opinion is the Stille plaster scissors with a straight cutting blade. Occasionally there is a sharp angulation at the front of the blade, which makes it difficult to run it under the plaster, and which is, moreover, unnecessary. This should be removed.

As a rule, it is wiser to make two lateral incisions, in order that a posterior shell may be left in which the affected part can rest until a satisfactory examination has been made and, if necessary, X-ray photographs taken.

The Toilet of the Skin after Removal. The skin is washed with warm water and soap, after which it is moistened with Eau de Cologne or ether. If desquamation is troublesome, vaseline may be rubbed in gently for a few minutes. This has the effect of softening the scales and the skin can then be washed with cotton wool moistened with a little ether. If there are signs of irritation of the skin—eczema or vesicles—applications of oxide of zinc or talc may be made for a few days.

The Making of a Plaster Mould or Cast. For the manufacture of certain braces, foot supports, and other apparatus, it is necessary to have a plaster-of-Paris model of the affected part. A covering of stockinet is applied, and fillets of metal laid over it along the lines of proposed section. A thin plaster case is then applied and immediately bivalved. Before actually removing the two halves a series of transverse pencil markings should be made at intervals across the lines of section to facilitate accurate coaptation later. When thoroughly set, the plaster segments are removed, handaged together, and allowed to dry. The model is now sent to a bracemaker, who fills the shell with plaster of Paris after lining the inner side with talcum powder, or a thin coating of soap. Sufficient plaster of Paris cream to fill the cavity is then poured into it. During the setting a strip or bar of metal may be placed longitudinally, so that when the cast sets this bar will be in place. Several inches of the metal project at either end so that the model can be handled easily. After removal of the case the mould is put in the oven until thoroughly dry. The bracemaker has now a positive impression of

the deformed part If the brace that is to be made from the mould is to be corrective in function, then the mould may be corrected by filling up concavities with plaster of Paris cream suitably coloured with mercuriochrome or some dye Abnormal convexities or bulges may be shaved off by means of a large knife, until the mould is corrected to the desired degree

CHAPTER 11

CONGENITAL DEFORMITIES

Congenital deformities arise in utero, and their mode of origin is largely conjectural. They are, on the whole, infrequent, and many are of only academic interest.

Mall divided congenital deformities into two classes—primary, or idiopathic, and secondary.

The *primary deformities* result from some inherent defect of the



FIG. 1—Bifid Thumb



FIG. 2—Bifid Thumb

fertilized ovum which spontaneously influences the development of the embryo. These errors may arise from an inherent peculiarity, weakness, or disorganization of the germ cells as is proved by their transmission through several generations. The belief that maternal impressions can bring about these developmental anomalies has no scientific justification.

In the *secondary congenital deformities* it is assumed that the foetus is at first normally formed but that later deformity is produced by the action of some extraneous cause—trauma to the pregnant mother, intra-uterine pressure, arrest or retardation of tissue-development as a result of nutritional disturbances in the growing embryo. Middleton has

lately drawn attention to the importance of muscular derangement in the mechanism of congenital deformity the errors of the bones being in the nature of structural adaptations to the primary error of the muscle. During the growth of the limb bud before the bony skeleton is evolved a bar of condensed mesenchyme becomes apparent at the situation where the skeleton subsequently appears. Gradually the mesodermal cells composing it are differentiated into cartilage and later into bone. At the same time surrounding mesenchymal cells become differentiated to form muscle cells the cells becoming oval and acquiring longitudinal striations. At this stage they are known as myoblasts. The transition from the myoblastic stage to the stage of fully developed muscle cell occurs at about the third month of intra uterine life and thereafter the history of the muscle is one of progressive elongation by which it keeps pace with the growth of the related skeletal tissues.

Middleton believes that the pathology of the muscular derangement may be of three types

- 1 There may be an arrest of development at the myoblastic stage
- 2 The muscles may develop normally but fail to elongate
- 3 The muscles fully formed may be the site of intra uterine degeneration with progressive conversion into scar tissue (Myodystrophia foetalis)

It is doubtful if syphilis is an important factor in producing congenital anomalies. The Wassermann test is positive in about the same percentage of children with congenital deformities as in those without and syphilitic stigmata are not observed more frequently.

Murphy has recently published a careful statistical analysis of data throwing light upon the aetiology of congenital malformations. His general conclusion is as follows. The observations which have been made during the course of the present investigation lead to the general conclusion that gross primary congenital malformations arise solely from influences which affect the germ cells prior to fertilization. No evidence is available to indicate that they result from factors which operate for the first time after fertilization has taken place.



FIG. 3.—Multiple Congenital Deformities

Both forearms are absent and both patellae are foot alows cal anco- arua, the 3 r al a no- alga s left rity

CONGENITAL DISLOCATION OF THE HIP

Congenital dislocation of the hip joint consists of a partial or complete displacement of the head of the femur from the acetabulum. It is the commonest and most important of all congenital dislocations, and constitutes about 2 per cent of all orthopaedic disabilities. The great majority of cases occur in girls. The hereditary factor is of importance.

ETIOLOGY

Congenital displacement of the femoral head may be the late effect of an osseous or muscular disturbance. The less common muscular type is the sequel to intra uterine muscular dystrophy (myodystrophia foetalis). The muscles attached to the proximal end of the femur become fibrosed and, failing to keep pace with the growth of the skeletal tissues, the pelvic bone almost literally grows away from the fixed femoral head.

The osseous type is the more frequent. It is due to a primary defect in the acetabulum and the dislocation of the femur is a secondary and incidental phenomenon.

The acetabulum appears as a condensation of mesoderm about the end of the fourth week of intra uterine life, but at first it constitutes only a shallow socket on the outer aspect of the developing innominate bone. Later, the socket is deepened by the progressive development of the original depression, and in particular that part of the socket which lies in the axis of the transference of weight—the postero superior part of the rim—becomes pronounced. It has been called the supra femoral buttress. The constant defect in congenital dislocation of the hip is an aplastic condition of this buttress, and it is instructive to note that in this characteristic the aplastic acetabulum resembles that of those lower forms where the hind limb has no postural function, and is not concerned with the transference of weight, e.g., the reptilia (Bruce).

The primary defect is readily demonstrable on dissection of new born hips, and is apparent on radiological investigation. From the viewpoint of treatment, it is important to note that the aplasia may be a temporary one, and that if the pressure is removed from the deficient area even after birth a subsequent restitution to normal often takes place—a fact that has been constantly stressed by Putti.

Many other theories have from time to time been advanced to explain congenital dislocation of the hip. Thus Jansen associates it with exaggerated intra uterine pressure and hydramnios, while others attribute it to a slighter degree of the muscular change which is admittedly the cause of the first type described. These views do not stand the test of investigation.

The Dislocation

If the view is accepted that the primary condition is a hypoplasia of the acetabular rim, then it is necessary to look upon the dislocation as a secondary effect and one that at some period may not be present.

When the defect in the rim is a pronounced one, the dislocation may occur in utero as a sequel to pressure or spontaneous and incoordinated foetal movement. In the lesser degrees of hypoplasia the head may still be in the acetabulum at birth, though an X ray even then will show evidence of the primary error. Post natal dislocation may occur soon after birth, when the legs are for the first time extended at the hip joint. Owing to the flexed position of the thighs in utero the anterior structures, and particularly the ilio psoas, are shortened. When first the child's limbs are extended, these shortened structures may act as the fulcrum of a leverage system, so that when the long arm of the lever (the femoral shaft) is depressed, the short arm (head and neck) is elevated, in this case, out of the acetabulum. Lastly, where the defect is only slight, the dislocation may not occur until the erect position is assumed. The first attempts at walking are then followed by a gradual upward displacement of the head on the dorsum ili. Bruce therefore believes that there may be three types of congenital dislocation.

- ✓(1) The ante natal type.
- ✓(2) The pre ambulant type.
- ✓(3) The post ambulant type.

In all of these cases the dislocation is upwards and backwards ○

PATHOLOGY

1 Changes in the Bones.

✓(a) The Acetabulum is shallower than normal, and at birth the only other error apparent is a gap or groove at its postero-superior part. Later, its rounded shape disappears the cavity being usually converted into a triangular depression, with its base in front and below, and its apex above and behind. X ray examination shows that the outer surface of the ilium and the floor of the acetabulum lie practically in a straight line, owing to the absence of the usual projecting rim at the upper part of the cavity. Instead of containing the head of the femur, the acetabulum becomes occupied by an over growth of fibro cartilage, the remains of the ligamentum teres, and the Haversian gland, and is covered over by the anterior portion of the capsule which is usually to some extent adherent to the floor. Above the acetabulum there is a depression on the dorsum ili, lined with periosteum, in which the head of the femur rests insecurely, a fold of the capsule intervening between the ilium and the head.

✓(b) The Head of the Femur is at first normal, but later it becomes small, atrophied, and flattened on its medial and posterior aspects. In some cases the atrophy is so extreme that there is practically no head present. If the head rests on the dorsum ili it becomes buffer shaped, otherwise it is conical. It is usually large in comparison with the acetabulum.

✓(c) The Neck of the Femur. There is marked shortening of the neck of the femur, which increases the shortening of the limb. The neck is also depressed and sometimes anteverted, so that the normal anteverision

of 12 degrees is increased until in late cases it may be almost 90 degrees, i.e. the neck appears to project straight forward from the shaft. As a result of this when the dislocation is reduced, the limb is rotated medially and the patella looks directly medially.

(d) *The Pelvis* When there is a bilateral dislocation the pelvis is



FIG. 4.—Congenital Dislocation of the Hip

This X ray shows a potential dislocation of the left hip. The nucleus for the head of the femur is in an abnormally lateral position on the left side and the acetabular rim is much more nearly vertical than on the right. This child has not walked but the hip will become definitely dislocated if weight-bearing is attempted.

tilted forwards and the normal lumbo-sacral lordosis increased. The whole innominate bone is small and atrophied and lies more vertically than normal so that the iliac crests are approximated and the ischia more widely separated.

In unilateral dislocation the corresponding pelvic bone is imperfectly developed and the whole pelvis has a lateral inclination, while the shape of the inlet is obliquely ovoid.

2. Changes in the Soft Parts.

(a) *The Capsule* Though not always evident, the capsule is said to assume an hour-glass shape, one cavity containing the head, the other covering the acetabulum, the constriction between them being produced by the ilio psoas tendon which crosses the capsule at this level. Through this narrow isthmus, the ligamentum teres passes. The lower part of the capsule is stretched across the entrance to the acetabulum, and, in some cases, is adherent to its contents. It will thus be seen that the capsule becomes a suspensory ligament for the pelvis, and, indeed, supports most of the weight of the body. It accordingly undergoes hypertrophy, particularly at its anterior and lower portions. The ligamentum teres is usually attenuated, and may be altogether absent.

(b) *The Muscles* There is considerable alteration in the muscles, indeed, this is one of the causes of failure to reduce the head into the acetabulum during treatment. Bruce divides the muscles into three groups—the pelvifemoral, the pelvitrochanteric, and the gluteal groups.

(i) *THE PELVIFEMORAL GROUP* This group runs in the same axis as the femur. As the head of the femur migrates upwards, they shorten, and thus form the most formidable obstacle to reduction. These shortened muscles are, the adductors, the hamstrings, gracilis, sartorius, tensor fasciæ latæ, and the rectus femoris.

(ii) *THE PELVITROCHANTERIC GROUP* This consists of the obturators, quadratus femoris, and the psoas tendon. These become functionally incompetent, since they are stretched and elongated. The psoas tendon, in addition, is displaced outwards, winds round the capsule, and acts as a suspensory ligament which supports the body-weight. Through its lateral displacement, an opening may be left beneath Poupart's ligament, through which a crural hernia may occur. This constitutes a Narath's hernia.

(iii) *THE GLUTEAL GROUP* These show little organic change, but since they are without their fulcrum their power is considerably diminished, while the displacement of the head leads to an alteration in their axis of movement.

CLINICAL FEATURES

Congenital dislocation of the hip has a definite sex and geographical distribution. Thus it is more common in girls—it is said because in the female the pelvic side wall is normally more perpendicular, with the result that the iliac buttress does not overlie the head so markedly as in the male. Further, the acetabulum has a more lateral inclination, and is normally more shallow. The incidence is high in some countries, especially those of Southern Europe—notably Italy.

Clinically, the condition is not usually observed till the child begins to walk, when the observant mother usually notices a slight lump. It should, however, be the duty of the accoucheur, the nurse, or midwife, to examine all children, particularly when the labour has been difficult, for abnormality at the hip joint. The condition might then be suspected

from the marked broadening of the perineum, or the swelling in the gluteal region due to displacement of the head of the femur

As the child continues to walk, the gait becomes more abnormal. The lump is peculiarly unstable, the trochanter ascending whenever the body weight is transmitted through the leg of the affected side

In the early stages there is neither pain nor tenderness, but passive and active movements of abduction and lateral rotation are limited



FIG 5



FIG 6

FIG 5 — Congenital Dislocation of the Hips.

Double disloc on in child of 10 The lordosis is well shown.

FIG 6 — Congenital Dislocation of Both Hips

The trochanter is prominent and there is a well marked lumbar lordosis.

The Gait In a bilateral dislocation the gait has been described as a "duck like waddle" or a "sailor's gait," and consists of an inclination to the side on which the weight is borne

In a unilateral case, the child lurches towards the affected side. The gait is the result of the inefficiency of the gluteal muscles, the shortening of the neck of the femur, and the displacement of the head, combined with the lordosis and the abnormal lateral mobility of the lumbar spine

The Lordosis This is particularly noticeable in bilateral cases, but is present in lesser degree in unilateral cases and is accompanied by a corresponding protrusion of the abdomen

The Deformity (a) Unilateral Cases There is marked shortening of the leg, which, on measurement, is found to be in the region above the great trochanter. The great trochanter lies above Nelton's line and is unduly prominent

(b) Bilateral Cases The legs appear too short for the body the perineal space is broadened, the trochanters are unduly prominent, and the buttocks broad and flat

EXAMINATION OF THE PATIENT

The waddling, lurching gait is at once noted. On inspection after stripping the alteration in the figure is apparent. In the unilateral case there is a marked prominence of the great trochanter, increase of

the lumbar lordosis, lack of development of the limb on the affected side, and asymmetry of the groove between the labia and the thigh. In the bilateral case, all these signs are present with the exception of the asymmetrical labio femoral groove and in addition there is an obvious broadening of the perineum

Palpation. On palpating the groins, it will be noticed that on the affected side the pulsation of the femoral vessels is difficult to feel (vascular sign). This is due to the displacement of the femoral head which normally supports the femoral artery. Posteriorly, the head can be felt in its abnormal situation. In some cases a Narath's hernia may be evident.

Movements Movements can be carried out painlessly and freely, except for some limitation of abduction and lateral rotation. In early



FIG 7—Congenital Dislocation of both Hips

There is marked broadening of the perineum

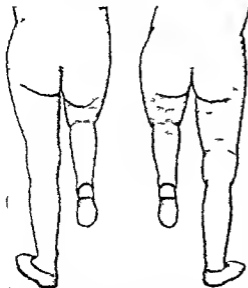


FIG 8—Trendelenburg's Sign
(a) (b)

Congenital dislocation left hip. (a) on lifting sound leg, buttock on that side drops. (b) on lifting dislocated leg, buttock rises slightly.

cases, a distinct telescoping can be elicited when the femur is moved up and down in its long axis, as this produces upward and downward movement of the head on the dorsum illi.

Measurements In unilateral cases, the affected leg will be found to be from 1 to 1½ inches shorter than the other, and even in bilateral dislocations there is usually some difference in length. The actual discrepancy varies with the amount of telescoping of the femur that

takes place. On closer examination it will be seen that the shortening is above the level of the trochanter.

✓ Trendelenburg's Sign This is elicited by asking the child to stand first on one foot and then on the other. In unilateral cases when she stands on the sound side the buttock of the opposite side rises slightly for the gluteus medius contracts in order to raise the pelvis and bring the trunk more directly above the limb which is sustaining the body weight. When she stands on the dislocated side, the opposite but



FIG. 9.—Bilateral Congenital Dislocation of Hip Joint

tock now drops, for the gluteus medius is relatively inefficient and the pelvis cannot therefore be raised or even be kept horizontal. The amount of drop depends on the degree of displacement and continues until the femur and the side wall of the pelvis of the side on which she is standing are brought into contact. Stability is then attained. In bilateral cases, the phenomenon is present on both sides.

The Trendelenburg test is not pathognomonic of congenital dislocation of the hip but occurs whenever the action of the gluteus medius is interfered with—as for example in infantile paralysis, and in coxa vara.

In congenital dislocation the inefficiency of the gluteus medius is due to two factors

(1) Its axis—normally vertical—is now altered to a more nearly horizontal direction

(2) Its fulcrum—the head of the femur—is now unstable

The X ray Appearance In taking X ray photographs of this condition it is important to obtain a stereoscopic view as well as the ordinary antero-posterior one. It is not difficult to demonstrate in this way, the dislocation of the head on to the dorsum ilii but certain other points should be investigated. The outline of the femoral head should

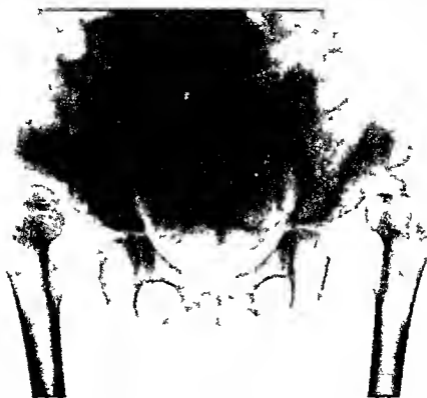


FIG. 10.—Bilateral Congenital Dislocation of the Hip Joint

be noted and it will be seen that the femur is displaced outwards and upwards. The epiphyseal shadow is usually smaller than normal and displaced outwards in relation to the neck. The neck is fore shortened and may be anteverted. Anteversion is investigated by taking two plates, one with the patella pointing straight forwards, the other with the leg in full medial rotation. Any anteversion is noted by the superimposition of the head on the trochanter in the first plate while the second shows the outline of the head quite distinct from the trochanter. The acetabulum appears less excavated than normal and, where its floor is on the same plane as the dorsum ilii it is flat shallow and shelves

upwards. The amount of upward displacement of the femur in relation to the acetabulum is of importance in the prognosis.

DIAGNOSIS

The history of a painless limp accompanying a child's first attempts to walk in the absence of a history of injury or antecedent disease, should suggest a congenital dislocation of the hip. There are certain signs that the practitioner or nurse should look for in infants, particularly female infants. In the unilateral cases there may be asymmetry of the groove between the labia and thigh of the gluteal creases, and



FIG. 11.—Diagrammatic Method of Determining Dislocation of the Hip

of the creases commonly seen in the skin and fat of the thighs of children. One hip may have a slender contour or be more prominent. The legs may be unequal in length, and this is well seen when the hips and knees are flexed for then the knees are not on the same level.

In the bilateral case the perineum is broader than normally and probably the thighs will not be in contact.

Thereafter an attempt is made to confirm the doubts by a careful palpation for those signs which are easily discovered in the older child.

After a careful clinical and radiographic examination there should be little difficulty in reaching a diagnosis but occasionally there are early or slight cases which leave a slight element of doubt. In such cases Bruce uses a helpful device to dispel the doubt.

A horizontal line is drawn on the radiogram through the clear areas which represent the triradiate cartilage and a vertical line through the edges of the acetabular roof.

If the condition is unilateral the vertical line is drawn on the sound

side and on the other a parallel is inserted at an equal distance from the mid line. Normally the capital epiphysis lies below the horizontal line and medial to the vertical (Fig 11, A). In potential dislocation of the hip it lies below the horizontal but lateral to the vertical (Fig 11 B) while in the fully established dislocation it lies above the horizontal and lateral to the vertical (Fig 11 C).

DIFFERENTIAL DIAGNOSIS

1 **Coxa Vara** Here the limp is less severe, the head is not palpable in an abnormal position nor is there any abnormal mobility. The shortening is constant and the X ray appearance is quite characteristic.

2 **Pathological Dislocation** In these cases there is usually a history of some previous hip joint trouble developing after birth. There is general limitation of hip movements. The X ray examination shows greater deformity and absorption of the head while the acetabulum is usually well developed.

3 **The Paralytic Dislocation of Poliomyelitis** This condition simulates congenital dislocation in its waddling gait and the shortness of the limb but the hip joints are normal and there is usually a history of febrile illness. There is obvious muscular paralysis. Any doubt should be removed by an X ray photograph.

PROGNOSIS

Although the condition is not a fatal one and in some cases in its early stages not even a seriously disabling one symptoms increase during the adolescent period and with increase of age and weight painful spasm and rigidity occur and at a still later date arthritis in the false joint. Platt reports on forty hip joints treated by manipulation at various ages from 1 year 7 months to 11 years. Fifteen were excellent thirteen good ten fair and two poor. The poor results were in children over 5.

TREATMENT

The treatment of congenital hip provides a grave orthopaedic problem and opinion is by no means unanimous as to the most efficacious solution. There is a variety of methods to choose from and the critical problems may be said to concern the vexed questions of operative and manipulative reduction and the advisability of supplementing such reduction by some reconstructive or retentive procedure.

It is of supreme importance to commence the treatment of this grave error with a well established conception of the aim and scope of surgical treatment.

The primary object is to reduce the dislocation and this should be accomplished whenever possible before the tissues have been irreparably deformed by the strains and stresses of weight bearing. Indeed treatment should be inaugurated at the earliest possible moment after a diagnosis is made for Putti has shown by his results that the deficient acetabulum may undergo spontaneous restoration to normal if the dis

location is reduced in the first few weeks or months after birth. This practice brings congenital dislocation of the hip into line with the treatment of other congenital deformities such as club foot. The reduction should also be carried out with the least possible damage to the delicate growing bones. In this connection it may be pointed out that even when the head of the bone has been accurately replaced great difficulty may be experienced in restoring joint function. The most frequent cause of this is certainly the use of undue force, or unduly traumatizing methods in replacing the head. Such methods are apt to invoke a series of irreparable changes in the growing epiphysis or in the opposing articular surfaces leading to fibrous adhesions or even to a condition akin to osteochondritis with resulting painful or limited mobility.

The question of supplementary reconstructive procedures is fully dis-

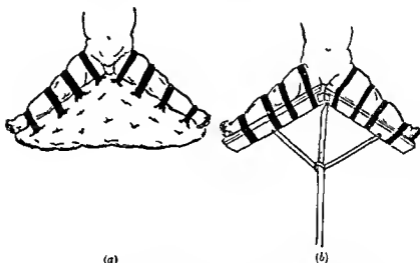


FIG. 12—(a) Putti's Mattress Splint (b) Putti's Adjustable Splint

cussed on a later page but it is all important that the period of fixation in plaster subsequent to reduction should be as short as possible, as otherwise changes may occur in bone, muscles, and joint surfaces, which may perpetuate or even add to, any permanent joint disability, in addition to prolonging considerably the already lengthy convalescence.

The aim of all surgical endeavour therefore, is—

- ✓ To reduce the dislocation
- ✓ To maintain the reduction
- ✓ To conserve as largely as possible, while so doing the function of the joint

Treatment in Early Cases

There are regions in Italy where congenital dislocation is so common that even the parents themselves look for evidence of the displacement. So afraid are they, that they will often bring their babies to the doctors for examination even when there is no sign of any dis-

placement, simply to have their minds set at rest. In these cases treatment can be begun at the most appropriate age, i.e. in the early weeks of life. In this country the condition is rarer and we seldom have the opportunity of commencing treatment at this optimum period.

Usually the separation of the head from the acetabulum is so slight at this early period that it is sufficient to put the limb in abduction of 45 degrees in order that the head may be opposite the acetabulum. It is enough to keep up this position for a few months to secure permanent reduction. This method is useful only up to the age of 12 months, and Putti, who advocates the procedure has cured 24 cases. His technique is as follows.

The aim is to keep a child of a few months old with the lower limbs abducted night and day for a long period. This is done by means of a



FIG. 11.—Bilateral Congenital Dislocation of the Hip showing the position after Reduction.

wedge shaped mattress rather firm and covered with waterproof cloth. The mother widens the mattress periodically to increase the abduction. The mattress is removed daily for cleaning and for giving the limb gentle manipulations into abduction and internal rotation. Every two months the child is X rayed and the treatment supervised. This treatment should be continued for at least six months and even though X rays are satisfactory before that it is wise to continue rather than risk a relapse. Putti now uses an adjustable splint which is simple, economical and allows progressive abduction more easily than the mattress. Both are depicted in Fig. 12.

The Method of Reduction The child is placed on her back on a low table, with the affected side near the edge, the pelvis and the opposite thigh being fixed by an assistant. In the case of a right-sided dislocation the operator grasps the leg with his right hand flexes the knee to a right angle, and then flexes the thigh to more than a right angle so that the

femur is vertical The head of the femur is thus guided to a position behind the acetabulum. The femur is now lifted vertically, and an attempt is made to lift the head into the socket, or at least to a position opposite it. The head can often be felt to ride over the posterior margin as it is lifted forward into the acetabulum. Whether the reduction is achieved or not, the adductors are now stretched by carrying the knee outwards till it touches the table. If the femoral head can be lifted over the posterior rim into the socket, the necessary degree of abduction will be obtained with much less stretching of adductors and with less trauma to the joint. If the lifting motion is unsuccessful, then forcible reduction is necessary to get the head well home into the socket. Abduction is carried out with a steady and increasing

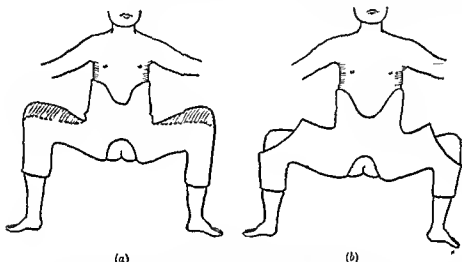


FIG. 14—The Retention of the Reduced Dislocation

- (a) Plaster applied to the limb in the frog position. The shaded areas are filled with cotton wool.
 (b) The plaster case after it is cut. The wool is removed from the extensor surface of the thigh and movement within the plaster are encouraged.

force, the trochanter being at the same time lifted forwards. Sometimes the *adductor longus* is torn by forcible kneading pressure of the thumb against its insertion. The reduction is recognized to be complete when an audible snap is heard and the head is felt to slip over the rim into the acetabulum. The depression which was previously present in the femoral triangle disappears, as the head, now levered forwards, fills the gap. It will also be noticed that the hamstring muscles are now taut and that the knee cannot be completely extended. Stability should be tested by releasing the limb and observing how easily or otherwise the hip redislocates.

Once the head is home the femur is rotated forcibly first in one direction and then the other, so stretching the various parts of the capsule to make sure none are caught between the bones.

This is practically the same method as that devised many years ago

by Lorenz, but it omits the forcible preliminary stretching of the muscles. The author believes that if any considerable stretching of muscles is necessary to ensure reduction there will ensue a degree of trauma to the epiphyseal end of the bone and extreme pressure on the cartilage conditions which will prejudice the result. If reduction cannot be carried out by the above method after two or three attempts, open operation is advisable

Instrumental aids to the reduction of the dislocation are only mentioned to be condemned as their use is fraught with very considerable danger.

In most cases, the younger the child, the easier is reduction. Occasionally however, a case of longer standing can be reduced with surprising ease. The cases which telescope easily are those which reduce easily, while excessive shortening is usually a menace to successful reduction.

Reduction may be difficult when the muscles are so shortened that the femoral head cannot be brought down to the acetabulum. Abnormalities of the joint capsule, such as an hour glass constriction or its attachment to the head or acetabulum, also prevent its proper reduction.

After-treatment After reduction the thigh is abducted to a right angle with the body until the medial surface of the knee lies on the plane connecting the anterior superior spines of the ilium. The amount of rotation is not so important though the patella is usually placed so that it points directly outwards from the body. A plaster of Paris spica is now applied from the nipple line to include both legs, even in unilateral cases. While the plaster is being applied the leg should be carefully held by the assistant and gentle pressure brought to bear on the back of the trochanter to keep the head forward in the acetabulum.

Dott uses a special modification which allows a certain amount of movement at the hip joint and yet retains the head in the acetabulum. This plaster is depicted in Fig 14. Before the application a large wedge of wool is placed on the anterior surface of the thigh with the broad part at the knee. This wool is included deep to the plaster when set, an oval window is cut out, exposing the knee. The wedge of wool is now removed and flexion and extension movements are encouraged. By this method there is less wasting of muscle less likelihood of the formation of adhesions in the joint and as a consequence, a much quicker return of function after the plaster is finally removed. A similar method is used at all subsequent stages of plaster fixation. In young children difficulty may be caused by the plaster becoming saturated with urine. The author, to obviate this difficulty, incorporates a metal frame in the posterior part of the plaster which serves to keep the plaster elevated from the bed. In this way, even when the bed is soiled, there is no saturation of the spica (Fig 15).

The day after the manipulation a radiogram is taken and the position of the hip verified. If the head is not in position and the case is a difficult one, it may be better to leave the plaster on for about a

week in order to stretch the muscles gradually. Reduction is then reattempted. If the head is in position, the child may be carried about in any way that does not cause discomfort.

In cases of double dislocation, it is a matter for judgement whether or not both hips should be reduced at the same time. The decision is based on the ease or otherwise of reducing the first hip. If this has been difficult, further manipulation may be attended by some risk, if, on the other hand, it has been carried out easily, it may be wise to reduce both at the same time, and so shorten the period of immobilization.

After the reduction, the case is carefully observed by X ray examinations and the state of the acetabular rim noted. In many of

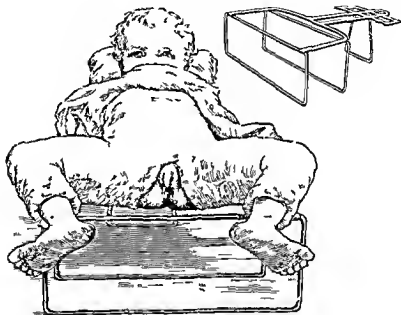


FIG 15—Apparatus for use with a Plaster of Paris case in Young Children. The Case is elevated from the Bed and Urinary Saturation is prevented.

the cases reduced at an early age, it will be seen that the hypoplasia of the rim disappears, and the rim grows and becomes more like the normal side. The first plaster is then kept on for three months, at the end of that time the angle of abduction and flexion is lessened, the thigh further rotated inwards, and a fresh plaster applied.

The second plaster is retained for three months, at the end of which period the leg is brought farther down and a third plaster applied for a further period of three months. After it is removed, attempts are made to restore motion to the hip. Radiant heat, diathermy, massage, and gentle exercises should be employed. Later on, re-education in walking is carried out. At this stage, it may be necessary to consider an osteotomy to correct any marked medial rotation resulting from the anteversion of the neck. This is best carried out about a year after the

manipulation, when a more accurate estimate can be made of the amount of correction necessary

In many cases and in the majority after the age of 2 years the acetabular rim does not reform and the hip though reduced remains in an unstable state. If nothing further is done such a hip inevitably redislocates, in those cases therefore a reconstruction of the acetabular rim should be undertaken. Most of the post ambulant cases require this operation.

The shelving or reconstructive operation so valuable in this type of case, will be described later.

In children after the age of four the possibility of reducing the head into the acetabulum becomes progressively remote. In all of these cases however manipulation should be attempted in the first place and if it is unsuccessful then resort may be had to either of the following methods.

(i) Continued Traction This may be applied by so called orthopaedic extension strapping and a Thomas's splint. Two pieces of strapping are applied to each lateral aspect of the leg. They overlap completely below and touch above so that they fit the cone shape of the leg. When this is applied an elastoplast bandage is applied from the foot to the thigh. The strapping is fixed to a spreader below and this to the weight or the Thomas's splint according to whether a sliding or fixed traction is desired. A very considerable tension can be applied to the leg by this means for the necessary time.

Traction is continued for ten to fourteen days and the leg gradually abducted and then manipulation may be attempted again. If an successful operative reduction is attempted.

(ii) Operative Reduction A modified Smith Petersen's approach to the joint is used. A curved incision is made in the line of, and just below, the iliac crest, extending from well back on the crest to the anterior superior spine and then passing vertically down the thigh for a distance of 3 or 4 inches. The interval between the sartorius and the tensor fasciae latae is sought and in this way the tensor is traced to its origin from the anterior superior spine care being taken to avoid the lateral cutaneous nerve of the thigh. The muscle, with a small portion of the cartilage is detached from the anterior superior spine, and an incision made down to the bone just lateral to it, and carried backwards along the iliac crest through the origins of the gluteal muscles. These gluteal muscles are now stripped off the ilium by subperiosteal dissection until the upper part of the hip joint is exposed. The anterior inferior iliac spine and the two heads of the rectus femoris are exposed and the outer divided thus exposing the capsule which encloses the dislocated head of the femur. The capsule is then incised parallel with the neck when on lifting up the edges of the wound, the narrow constriction is seen leading downwards and medially to the shallow acetabulum. The incision is prolonged through the constricted area to allow the femoral head to be levered or lifted into its socket. The capsule is now reefed

and sewn at right angles to the incision, and the muscles carefully sutured together, the glutei being sutured to the lateral abdominal muscles along the crest of the ilium. The hip is put up in full abduction with flexion to a right angle of the knee and hip in a plaster of Paris spica. Neither remodelling of the head nor gouging of the acetabulum should be practised, as they only lead to limitation of movement in the joint afterwards.

After treatment is on lines similar to that following manipulation, but the period in plaster is shorter.

The Reconstructive Operation

This operation is indicated in those cases in which the X ray shows marked shallowness of the acetabulum or a small irregularly shaped head. It should also be carried out in cases which redislocate after a primary reduction. A similar type of operation is also carried out in cases which cannot be reduced, an attempt being made to form a new acetabulum on the dorsum ili.

THE OPERATION

The region of the hip joint is approached by a Smith Petersen incision in the same way as in the open operation for reduction.

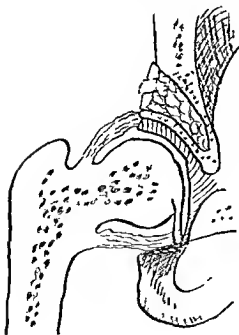


FIG 16

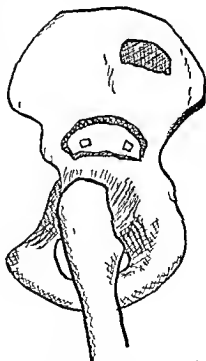


FIG 17

Figs 16 and 17—Reconstruction Operation for the Hypoplasia of the Upper Acetabular Rim

Attempts will have been made to reduce the dislocation by the manipulative method but where this has not been successful it is reduced in the first stage of this operation. It is an advantage to open the capsule of the joint even though there has previously been good reduction. It enables the exact site of the shelf to be ascertained with precision.

The thick soft periosteum and fibrous tissue which form the remains of the capsular pocket which had accommodated the head when dislocated are now stripped downwards off the ilium until the acetabular cartilage is exposed the false socket being thus entirely denuded. Most of this tissue should be trimmed away to leave only a fairly thick capsule on the upper surface of the joint.

A gouge is then applied to the ilium a few millimetres above the acetabular margin and an incision made in a crescentic fashion to correspond to the outline of the upper half of the acetabulum. Care should be taken that the important posterior half of the acetabular brim is reformed.

The upper half of the acetabulum is then dug out of the ilium by the gouge and levered down over the head of the femur to form a hood. This step is the most important one in the whole operation. It is essential that no gross projecting ledge is formed over the head. Rather the normal size of the acetabular roof is restored partly by prising down a narrow strip of ilium but more by digging the upward sloping superior half of the socket out of the innominate bone.

A large circular portion of bone is now removed from the posterior part of the dorsum ili consisting of the outer table and cancellous bone the ooze from the cut surface being checked by bone wax. A portion of this graft is cut to form a crescentic plate which will bridge the gap between the ilium and the restored acetabular margin (Fig 17). The remainder of the graft is cut into small chips or fragments and these are inserted so as to fill the space from which the acetabulum has been pressed outwards. The crescentic plate is then laid over this chip-filled interval one edge of the plate being fixed under the cut margin of the ilium and the other lying end on against the upper and back edge of the acetabulum.

After its position has been accurately secured it is fixed in situ by a pair of ivory pegs passed through it into the ilium.

The operation is now completed and the reconstituted acetabular margin should be quite small—very little if at all in excess of the normal rim of an acetabulum.

The musculo cutaneous flap is then restored the tensor fasciae latae is resutured to its former origin, but the gluteal muscles are more easily sutured to the lateral abdominal muscles which bulge over the crest.

It is wise in order to give strength to the scar to suture the subcutaneous tissues separately thereafter the skin edges are approximated.

A plaster spica is then applied with the hip abducted to prevent any undue pressure by the head on the newly formed roof. The plaster

however need not be retained for as long as after the manipulative reduction. The child may be allowed to walk six or nine months after the operation

The Irreducible Adolescent Case In the case of an adolescent where reduction by any of these methods is impossible the decision as to the best type of treatment is most difficult. Where the child is active and free from pain and especially if the condition is unilateral it is probably wise to leave well alone as operative treatment may result in a stiff and painful hip. Even in a patient of 10 or over where reduction fails it is best to advise nothing more than a raising to equalize the length of the limbs operation being deferred until pain and instability occur. It is doubtful whether anything is to be gained by forming a shelf above a displaced head though some authorities believe it gives more stability. It however does not alter the lordosis produced by the backward displacement of the head and this is what will give the first symptoms of trouble. Apart from reduction the only treatment likely to help this is a subtrochanteric osteotomy angulating the shaft or the neck so that the shaft comes to be anterior to the head plane.

The Treatment of Old Unreduced Cases

These old unreduced cases come to hospital at ages between 20 and 30 complaining of pain in the lower back pain in the dislocated hip shortening limb and with their general endurance and capacity for work greatly reduced. There is usually marked atrophy of the bone absence of any bony socket and shortening of muscles by several inches.

(a) *The Treatment of the Unilateral Case* In old cases where reduction is impossible the best palliative treatment is the bifurcation osteotomy of Lorenz which serves to prevent weight bearing at the painful false joint. (See Fig 702) An incision is made on the lateral aspect of the thigh at the level of the anterior inferior iliac spine. The femur is divided obliquely from the lateral aspect upwards and inwards to give a broad overlapping surface of raw bone. The limb is then abducted and the upper end of the lower fragment inserted into the acetabulum the position being maintained by plaster. After union has taken place between the two raw surfaces the upper end of the femur is Y shaped or as the operative name implies has a bifurcated end upon which the pelvis rests. The abduction diminishes the apparent shortening considerably while the weight of the body is now supported by bone instead of by soft tissue.

Schanz has suggested an alternative procedure. He pointed out that in congenital dislocation of the hip the pelvis drops on the sound side when taking the body weight on to the forward foot in walking on the dislocated side and tilts till the femur on the dislocated side impinges on the lower border of the pelvis after which stability is secured. If the femur is divided at the level of the lower border of the pelvis and angled so that the upper fragment is applied to the side wall of the pelvis and the lower fragment parallel to the long axis of the body the lurching gait

will be diminished since the stable position is at once present. It may then be supposed that the gait will be improved, and the Trendelenburg sign improved. Other factors in the improvement are the slight depression of the trochanter which improves the leverage of the glutei, the displacement of the point of pelvic support to a site medial to the false joint—which also improves the leverage of the glutei, and the friction between the femur and the pelvis.

THE OPERATION Prior to the operation an X ray is taken with the hip joint in full abduction and with a measuring rod alongside it,

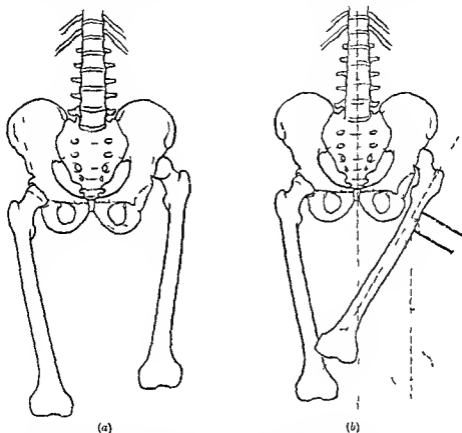


FIG 18—Schanz's Osteotomy

- (a) The position of the dislocated side before weight is borne on this foot
 (b) Shows the adduction of the femur towards the pelvis till stability is reached. The site and method of the osteotomy is evident.

and it may be easily ascertained now at what angle the bones should be fixed to get the best result by simply drawing on the X ray a straight line from the point of section parallel with the opposite leg. A vitalium plate is now prepared, angled laterally to this degree in one plane, while to compensate for the backward position of the head, i.e. behind the acetabulum, the plate is also angled in an anterior plane to about 30° . The femur is exposed by a lateral incision with its centre approximately near the point of bone section. The point of section is ascer-

tained by measurement on the X ray with the measuring rod and is marked. The suitably angled vitalium plate is now screwed home on the upper part of the femur. An osteotomy is now carried out by drilling several times through the bone at this site and completed by a narrow osteotome. The lower fragment of the femur is now brought into alignment with the lower angle of the plate and the latter is screwed home. A plaster spica is applied for three to four months.

It is important not to employ this method under the age of 15 as the pull of the adductors while the bone is growing in length may lead to loss of the femoral angulation.

A complication of this method which the author has seen is a secondary arthritis between the adducted upper fragment of the femur and the pelvis. It may even occur between the lesser trochanter and the rim of the original acetabulum.

(b) *The Bilateral Case* In the treatment of the old unreduced bilateral case there is a choice of two methods.

1 A shelving operation may be carried out on both sides so that an upper rim is made for the false acetabulum. This stabilizes the joints, takes the weight off the soft tissues and in some cases gives a good result.

2 Cases have been described in which a bifurcation operation has been done on both sides with remarkably good functional results.

3 A bilateral Schanz osteotomy may be performed and as it improves the weight bearing alignment it helps the patient considerably. The Schanz osteotomy has greater precision in the amount of angulation while the Loreuz osteotomy is very efficient if the femoral shift can be made to engage in the acetabulum.

Complications

Certain complications may follow the treatment of congenital dislocation of the hip. Some of these are the result of the operation itself while it is doubtful if some of the others are due to the operation or are merely coincident. As a direct result of the manipulative treatment fracture of the femur sometimes occurs and occasionally the sciatic nerve may be bruised. The hæmatoma which sometimes occurs after damage to muscles may suppurate. Fairbank describes two such cases.

Osteoclondritis deformans juvenilis may occur after reduction of a dislocated hip but cases have also been recorded of the condition occurring in the normal hip in unilateral cases.

Arthritis Pain and stiffness of the hip due to arthritis not uncommonly follow manipulative reduction particularly where the manipulation has been carried out with considerable force. A further degree of arthritis may result in complete ankylosis.

Displacement of the Epiphysis It is a curious fact that so few cases of displacement of the epiphysis of the femoral head are recorded. The

author is unable to find any statistics of the incidence of this complication. This strongly supports the pathological theory of the etiology of slipped upper femoral epiphysis.

CONGENITAL GENU RECURVATUM

(Congenital Dislocation of the Knee)

The condition, known since the time of its first description by Chalel as congenital dislocation of the knee, is now known as congenital genu recurvatum. Considerable light has been thrown on its origin and development by Middleton who has shown that the essential feature is an intra uterine degeneration (*myodystrophia foetalis*) affecting the quadriceps extensor of the knee. The contracture may co exist with other deformities of like nature—clubfoot, clubhand, and congenital hip—and it acts by dragging the knee into the recurved position during the period of intra uterine growth. At first only the knee is recurved. Later as the muscle becomes progressively contracted the tibia may be pulled up in front of the femoral condyles.

Previous views that it was the result of harmful intra uterine pressure, and that it was caused by separation of the distal epiphysis of the femur, are now untenable.

CLINICAL FEATURES

The knee is fixed in hyperextension and the skin over the anterior aspect of the joint shows several transverse creases. The patella is small or absent. On the posterior aspect of the joint the hamstring muscles are palpable as tense cords and the femoral condyles are felt projecting in the popliteal fossa. The joint is relatively fixed. When attempts are made to flex it, an elastic resistance is appreciated—this is the quadriceps tendon.

TREATMENT

If begun shortly after birth, it may be possible to stretch the shortened quadriceps and replace the tibia in mild cases. If this method is adopted, care must be taken not to attempt too much flexion at the start—the amount should be increased from day to day, and the correction maintained by adhesive plaster bands applied from thigh to foot.

There is as in other muscular deformities, a strong tendency to relapse, while in the more severe cases manipulation will be insufficient to overcome the contracture. In this case, operative division or lengthening of the quadriceps and its lateral expansion—and occasionally of the ilio tibial tract—will permit of replacement. After this procedure there is apparently no tendency to relapse.

After operation, the corrected position is maintained by a splint or light plaster case, and when the child begins to walk care should be taken to avoid, by appropriate splinting, the subsequent development of a

knock knee This is particularly prone to occur because of the imperfect nature of the ligaments of the knee joint

CONGENITAL ANGULATION OF TIBIA

(Congenital Tibial Kyphosis)

In this condition, the tibial diaphysis on one or both sides shows marked anterior angulation. Middleton has drawn attention to other concomitant anomalies, viz a persistent pes equinus, and some apparent atrophy of the affected limb or limbs.

The error is often associated with other congenital derangements, such as absence of the fibula or congenital hip

ETIOLOGY

It is believed to be a result of failure in growth in length of the calf muscles, which remain short, pull on the heel, and produce a rigid equinus deformity. When the ankle joint is plantar flexed to its farthest limit, the strain falls on the cartilaginous tibial diaphysis, which becomes angled at its weakest point. As soon as the tibia becomes ossified, the angulation ceases.

Congenital angulation of the tibia has also been attributed to intra-uterine pressure, constriction by amniotic bands, and to the healing of an intra uterine fracture. It has even been thought to be related to the condition of congenital pseud arthrosis of the tibia, but the errors have nothing in common save their site.

TREATMENT

Since the condition is fully established and maximal at birth, it should be treated at once. The tendo calcaneus may be tenotomized or lengthened to relieve the equinus displacement, and if necessary the tibia straightened later by osteoclasis or osteotomy.

CONGENITAL PSEUD-ARTHROSIS OF THE TIBIA

This is a fairly common congenital error which is notable for its resistance to all treatment. The child is born with what appears to be a fracture of the tibia which fails to unite.

PATHOLOGY

The pseud arthrosis is situated usually at the junction of the middle and lower thirds of the tibia. The ends of the bone are sclerosed, and there is a considerable gap between the fragments occupied by fibrous tissue. The leg is therefore much shorter than its neighbour. As in ordinary transverse traumatic fractures of this region, there may be considerable overlapping which may mask the extensive loss of substance which the tibia shows.

ETIOLOGY

The essential nature of the error is the aplasia of a portion of the tibial shaft, which most likely arises as a sequel to a nutritional disturbance. It has also been suggested that it results from intra uterine pressure or from constriction by amniotic bands (Codivilla) and that there is a deficiency in the nutrient artery so that the bone cells fail to exercise their normal osteogenic capacity.

TREATMENT

This is usually unsatisfactory and the majority of cases require amputation. Putti in a communication to the French Congress of Surgeons in 1922 reported 11 failures in 13 cases.

Short of amputation there are two possible methods of treatment (1) by shortening the leg sufficiently to get good approximation and side to side apposition of the fragments, and (2) by some method of bone grafting. The various methods in use are

(a) Cutaneous osteo periosteal pedunculated grafts swung over from the side of the tibia as practised by Codivilla

(b) The massive inlay method of Albee

(c) The osteo periosteal graft swung down from the upper fragment

Henderson reported two successful results out of five cases. He thinks that the later the fracture has been sustained the better the operative result.

Before operation the child should be in the best possible state of health. He should be walking with a caliper splint so that the lines of weight bearing are as nearly normal as possible. Massage of the part should be carried out to stimulate the circulation. Heliotherapy in the summer, ultra violet light therapy from mercury quartz lamps in the winter and contrast baths of hot and cold water, are also useful adjuncts. Cod liver oil should be given almost continuously and the diet should contain a sufficiency of the essential vitamins and of calcium phosphate.

Radiograms should be taken at frequent intervals to estimate the increase in metabolism as shown by the size and density of the lower fragment. Henderson advises that operation should not be undertaken earlier than the sixth year and that it is better to wait until puberty, or even later.

CONGENITAL TALIPES EQUINO VARUS

(Club foot)

Congenital talipes equino varus is a deformity in which the foot is turned inwards to a varying degree. In its most characteristic form there are usually said to be four elements of deformity ① flexion of the ankle ② inversion of the foot ③ adduction of the forefoot and ④ medial rotation of the tibia. Slighter degrees of deformity are met with, however and to these the name of congenital club foot is equally applicable.

ETIOLOGY

Club foot may result from an osseous, a muscular or a neuropathic error or may be termed idiopathic. Of these the last is by far the most frequent and will be discussed first.

The Idiopathic Type

As a rule it occurs in otherwise normal infants but occasionally other congenital deformities are present indicating the developmental origin of the condition. It is more frequently bilateral than unilateral. The following theories have been advanced to explain the actual cause of the deformity.

1 Increased Intra uterine Pressure This is the oldest theory and according to it the deformity begins as a malposition in utero this is made permanent by undue pressure on the foot by the uterine wall probably as a result of a deficiency in the amniotic fluid.

Objections are usually raised against it on the grounds that the uterus is not a rigid chamber but one which accommodates itself to its contents and twins are rarely affected. Further the foetus is supposed to be constantly changing its position and moving its limbs so that continuous pressure on any one part is hardly possible.

✓ Denis Browne a supporter of this theory points out that normally at birth there is a slight calcaneal deformity since pressure is exerted on the sole of the foot in the folded leg position of the foetus. This is quickly corrected because of the relative power of the calf muscles. If abnormal pressure is brought to bear on the foot in the normal position however the outer border of the foot takes the major part of the pressure and longitudinal bending of the foot occurs that is an adduction of the forefoot. As the pressure increases the force exerted on its outer border causes the whole foot to be swung into varus and owing to the inclination of the joint surfaces into equinus as well or in rare cases into the most severe degree of the deformity which Browne recognizes in which the great toe is pointing directly upwards along the tibia and there is gross varus but no equinus deformity. In support of this view Browne attaches importance to the dimples over the bony prominences which are an invariable feature and have their normal counterparts in the dimples over the elbows the knuckles and the posterior superior iliac spines. He stresses the importance of the fact that treatment based on this conception of the error is more uniformly successful than any other.

✓ 2 Hereditary Defect In support of this theory it is quoted that the condition appears to have a definite familial and hereditary incidence. Thus Adams records a case of a man with club foot who had five children one nephew and one grandchild all similarly affected. ✓ Brockman its main advocate has stressed the fact that the deformity in the main consists of a dislocation of the head of the talus out of the socket formed for it by the navicular sustentaculum tali, and the

plantar calcaneo navicular (spring ligament) He contrasts the deformity with congenital dislocation of the hip and believes that in congenital talipes equino varus there is an aplasia of the socket due to non separation of the navicular from the sustentaculum tali

PATHOLOGICAL ANATOMY

The typical congenital club foot is at first a deformity of soft tissue only. Browne has pointed out that three degrees of the error may be distinguished in the first adduction of the forefoot is the only error, in the second degree inversion and equinus are present as well as the adduction while in the third degree when the toes are pointing directly upwards and the sole is in contact with the medial surface of the tibia there is inversion and adduction of the forefoot, but no equinus element in the deformity. Over the skin on the outer part of the foot there are usually dimples which may be so marked as to resemble scars. The lateral malleolus is prominent the medial appears flattened and poorly developed.

The Muscles and Tendons The muscles are poorly developed and the tendons delicate. The tendo calcaneus passes downwards and outwards to its insertion into the calcaneus while the plantar muscles, especially on the medial side, are tensely contracted. The anterior muscles of the leg are elongated.

The Ligaments The ligaments on the medial and inferior surfaces of the talo calcaneo navicular joints are contracted, the plantar calcaneo navicular ligament being very small and short. The deltoid ligament of the ankle joint is similarly affected.

The Bones Bony changes appear as a result of the long continued contraction of the soft parts. They are at first confined to the talus but subsequently the calcaneus, the navicular and the cuboid become appreciably altered.

(i) **THE TALUS** A large portion of the upper surface of the talus escapes from between the malleoli and becomes prominent on the dorsum of the foot. This portion, now free from pressure, becomes broadened, and, in severe cases, is an obstacle to passive dorsiflexion of the foot even after the soft structures have been stretched or divided. The



FIG 19 — Bilateral Congenital Talipes Equino-Varus.

Baby 3 months.

head and neck of the talus are deflected downwards and medially, carrying the navicular and the forefoot with them

(i) THE CALCANEUS The calcaneus becomes tilted so that its medial tuberosity approaches the medial malleolus. Its vertical height is less on the medial side, and the anterior part of the bone is deflected medially following the direction of the neck of the talus

(ii) The navicular and the cuboid are displaced inwards. The phalanges are plantar flexed

It has been the usual convention to suppose that the tibia was medially rotated. This however is not an obvious feature in the majority of cases and Denis Browne states that in his experience it never occurs

CLINICAL FEATURES

In unilateral cases the deformity is never very severe, but the leg is obviously smaller and less well developed than on the healthy side. The skin of the foot may be normal though stretched and thin on the dorsum and thrown into creases along the medial border and on the sole. In addition there may be signs of external pressure on the dorsum in the shape of scars. The head of the talus can be felt on the dorsum of the foot. The lateral border of the foot is convex and the medial concave. The forefoot is plantar flexed upon the hind foot. The heel is rotated medially and may be drawn upwards throwing the whole foot into equinus. In many cases a well marked genu valgum is present. The patient walks with a stumbling gait which lacks elasticity. Bursae and callosities develop over the weight bearing areas. When bilateral the deformity is rarely equal since according to Browne, the foot on the outer side of the cross legged position is always 10 per cent worse than the sheltered one. He points out that the primary and constant deformity is the curving inwards of the sole and heel round a perpendicular axis, and that the equinus and varus elements are secondary and inconstant.

DIAGNOSIS

The diagnosis is usually easy but it is well to remember that an inverted position of the feet is frequently assumed by young infants. If this can be easily over corrected by gentle manipulation the existence of club foot can be excluded

In all cases search should be made for spina bifida and for evidence of poliomyelitis

PROGNOSIS

Without treatment, the deformity increases, the gait becomes more unsightly and the foot more troublesome on account of callosities and ulceration

With early effective and continued treatment all cases of club foot should be cured and a useful and properly shaped foot obtained. In older children the condition should be greatly improved

TREATMENT

The objects of successful treatment are two in number ① the deformity must be reversed and ② the muscular power of the limb developed to a sufficient extent to maintain the correction. This implies constant supervision until the period of growth is over as there is a distinct



FIG. 90.—Congenital Talipes Equino-Varus
Associated with polydactyly and bowed tibiae.

tendency to retrogression. The mode of treatment varies with the age and the extent of the deformity. The important point is to get the forefoot deformity corrected so that it points outwards 20 degrees as in the military position of boxing. If the forefoot is used correctly it will grow from its inward bending to perfect straightness and normal size. Correction of this part of the deformity with support and rest is the secret.

1 Treatment in an Early Case

The treatment should be begun as early as possible. Brockman points out that the ideal time to start treatment is when the child has adapted himself to an independent existence i.e. a week to ten days after birth.

The Method Manipulation frequently repeated is the method of treating the deformity in an infant. The adduction of the foot is corrected by the hands of the operator up to the age of two. The infant lies supine on its mother's lap while she protects the knee and prevents any strain from falling on the ligaments by grasping the upper end of the tibia. While one hand fixes the heel, the other reduces the adduction of the forefoot. To do this the thumb of one hand

rests on the talus and acts as a fulcrum while the other hand presses the forefoot into abduction. The maximum result is maintained for a few seconds at each sitting.

After the age of two the foot is too rigid and Browne advises a woodworker's vice with a notched block of wood on one side of it and a wedge on the other. The foot is placed between the two blocks and the deformity reversed by forcing

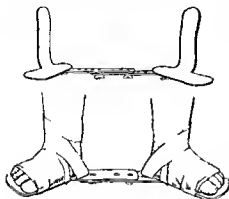


Fig. 1—Denis Browne's Splint

the foot into the notch so that it has a longitudinal bend convex inwards instead of outwards.

The foot is then forced into a calcaneo valgus position by the full force of the hands. In the case of the right foot the surgeon's right thenar eminence is placed below the great toe and the four fingers curled round the heel with the palm of the hand over the external malleolus and the tips of the fingers on the tendo calcaneus. When the feet are too stiff Browne uses an instrument like a pair of nut crackers the one essential mechanical point about them being that the axis of the hinge joint that connects the two limbs must coincide with the axis of the ankle joint. The limbs of the "nut crackers" are stout oak boards the hinges are bolts joined together by eyes at their ends. By means of butterfly nuts on the bolts it is possible to control the position of the hinges and the inclination of the boards to each other to suit different cases. The patient's leg is strapped to the lower oak board of the nut cracker by sticking plaster, the foot turned outwards to a suitable degree against the upper one and then they are forced together.

The Method of Splintage After manipulation some form of splint must be used. A light lateral splint of aluminium covered with lint is sometimes applied to the outer side of the leg and foot. Attempts to maintain the correction by zinc oxide plaster have also been made.

Denis Browne points out that fixation in these types of appliance tends generally to produce immobilization of the foot and therefore the muscular recovery is inhibited rather than assisted. He has designed a splint which allows of full correction of the deformity and

at the same time encourages the activity which is so important from the point of view of the muscular development. He maintains that the important element of the deformity is the longitudinal bending of the forefoot. If this is completely corrected the calcaneal deformity is automatically improved and the equinus also tends to disappear. The essential of the method is that the feet are connected horizontally at any desired angle to the sagittal plane of the body. To hold the

feet an L shaped piece of aluminum is cut and bent up one side. This is put on so that the bent part is applied to the outer side of the leg while the remaining limb of the L lies against the sole of the foot. After the manipulation the splint is applied and kept in place by a few turns of sticking plaster while each foot splint is fixed by a friction joint at a satisfactory angle to an aluminum cross bar. If the club foot is unilateral the normal foot should be fixed to the cross bar so that it is turned outwards at an angle of 20° , that is at its natural inclination. In the case of the club foot the splint is fixed so that the toes are directed outwards at an angle of 90° from the sagittal plane. The splints



FIG 2 —Congenital Talipes Equino Varus

The deformity has been corrected by manipulation and a plaster case has been applied. Note that the case extends from the mid thigh to the toes.

should be removed once a fortnight and an opportunity taken then to manipulate the foot. In Browne's opinion treatment by this splint should be continued for about nine months. The child is encouraged to kick and to stand up as much as possible in the splint. When he is capable of holding the feet naturally in the corrected position and the feet have the full range of movement the sticking plaster and the aluminum splint are discarded and replaced by a pair of boots riveted to the aluminum cross piece to hold the feet in the same position as they occupied in the splint. These boots have open toes and unlace completely from one end to the other. In consequence there is no need for complicated fittings and one pair will last the child for the complete period of treatment the toes simply sticking out of the open ends as the feet grow. It is often helpful in retaining the correction to reverse the boots, wearing the right boot on the left foot.

If it becomes apparent after a period of some months that the

equinus deformity has not been completely overcome it is occasionally necessary to divide the tendo calcaneus by subcutaneous tenotomy. Occasionally the plantar fascia may also require to be divided. After such operations the foot and leg are encased in plaster of Paris with the foot in the over-corrected position, the knee flexed, and the leg laterally rotated. The plaster is carried up to the middle of the thigh and is worn for three or four weeks (Fig. 22).

Denis Browne points out that plaster, by completely immobilizing the limb retards or inhibits the recovery of the muscles and he is also averse to tenotomizing operations as these do still further damage to the muscular tissues. He recommends that forcible correction be obtained in these cases by means of a vice and that thereafter plaster may be employed for a few days until the effects of the operative or manipulative trauma have passed off, following which the child should straightaway be placed in his form of splint or in the special form of boot which he recommends.

The deformity may be considered as cured when there is no adduction or inversion deformity when there is a hollow on the dorsum of the foot in the position previously occupied by the head of the talus and when the child is able to evert and dorsiflex the foot voluntarily to about a right angle.

2 The Treatment of Older Patients, hitherto untreated

The older the child the more resistant is the deformity. Treatment by manipulation therefore, requires to be carried out under

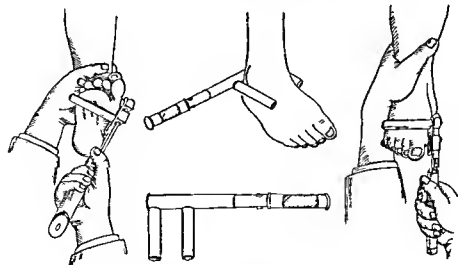


FIG. 3—The Thomas's Wrench

Used in the treatment of Club Foot. Stages in its application. (Whitman.)

general anæsthesia. The foot is manipulated with a Thomas's wrench or by Browne's instruments but the various movements are the same as those effected manually in a younger child.

The correction is complete when the soft parts are completely lax and the whole foot lies quite limp. It may not be possible to mobilize the foot adequately at one sitting in which case it will be necessary to repeat the manipulation. After the operation the foot is fixed in the position of the greatest correction that can be obtained by means of plaster of Paris. The plaster is carried from the toes to well above the knee joint which is flexed.

In some cases complete correction will be obtained by this method but in older patients it is seldom possible to rectify the deformity completely by manipulation alone, in these tenotomy of the plantar fascia and the muscles and elongation of the tendo calcaneus may be necessary.

Once the deformity is corrected physiotherapeutic treatment is instituted to mobilize the joints and to develop the muscles. In the intervals the foot is kept in the corrected position by means of a Browne's splint. When the child is allowed to walk the lateral side of the sole of the shoe is raised to keep the foot in good position. The use of the splint is continued during the night for many months.

3 The Treatment of Old and Relapsed Cases

However early and however thoroughly congenital club foot is treated in a certain percentage of cases because of rigidity or a constant tendency to relapse manipulative treatment will not suffice.

Although a plantigrade foot may still be obtained by manipulation the heel will remain inverted and the navicular will still be in close contact with the medial malleolus. Any correction that takes place is between the cuneiform and the navicular instead of between the navicular and the sustentaculum tali. To ensure a good result in this type of case an operation is necessary.

The Open Operation of Brockman A tourniquet having been applied to the limb an incision is made on the lateral side of the foot, along the calcaneus. Through it the plantar muscles and fascia are detached from their origins as far backwards and medially as possible but they are not divided as in Steindler's operation. A second incision is then made on the medial side of the foot and the remaining attachment of the muscles completely erased. The tendon of the triceps posterior is identified. It may be necessary to detach it from the tubercle of the navicular although this should be avoided if possible as it is apt to be followed by dislocation of the bone. The soft tissues are now dissected off the inferior surface of the tarsal bones until the whole of the inferior and medial surfaces of the navicular and the medial surface of the sustentaculum are exposed. The navicular is now mobilized by dividing the ligaments on its medial, inferior and if necessary, its superior surface. The deltoid ligament of the ankle and the plantar calcaneo navicular ligament are usually divided. The foot is then manipulated so as to bring the navicular in front of the head of the talus.

The incisions are now closed and plaster is applied with the foot just short of full correction. Complete correction can be secured a

fortnight later when the plaster is removed and the foot manipulated without removing the stitches. At this time, too, the tendo calcaneus may be tenotomized if necessary. A second plaster is now applied for about eight weeks, at the end of which time an ordinary boot is



FIG. 24 — Arthrogryposis Multiplex Congenita

The ulnar club hand and the talipes are evident. Both patellas were absent in this case.

fitted and the patient allowed to walk. At night he should still wear a club-foot splint. Exercises are given to increase the power of the muscles, to teach the child to walk properly, and particularly to evert the feet.

4. Treatment in the Adult Patient.

In the adult, no manipulation, tenotomy, or muscle operation is likely to be of benefit, operation on the bone is necessary in most cases. This is done, however, only after the maximum amount of improvement has been obtained by manipulation and by operations on the soft tissues.

The Operation (Cuneiform Tarsectomy). A straight incision is made from below the lateral malleolus along the dorsum of the foot, exposing the calcaneus and the mid tarsal joint on their lateral aspects. A wedge of bone, with its base laterally, is now removed from the calcaneus, behind the mid-

tarsal joint, a similar wedge from the cuboid in front of the joint, and finally a curved wedge with its base upward and laterally, from the head and neck of the talus. An incision is then made on the medial side of the foot and the talonavicular capsule and the deltoid ligament divided. It should then be possible to manipulate the foot into the correct position without undue force.

The foot is encased in plaster which should reach the knee. This is applied for six weeks although it may be necessary to change the plaster at the end of a fortnight in order to over correct the deformity as in the treatment of the relapsed case.

In some cases the best result will be obtained by stabilizing the foot as in the operation of Naughton Dunn. Here the mid tarsal and sub taloid joints are arthrodosed as in some forms of flat foot (See Pohlmyehtis)

Other Types of Club foot

1 The Muscular Type A type of club foot occurs in that rare congenital affection of the legs and arms which was first described by Sterne as *Arthrogyposis multiplex congenita* but has since been renamed by Middleton *Myodystrophia foetalis* (qv). The foot deformity is extreme the foot is a whole being more rigid than in the ordinary type of congenital club foot. The toes are flexed into the sole and can only be straightened with great force. Recurrence of the deformity takes place whenever the force is released. The leg and thigh are thin and the amount of muscle tissue is diminished. There is usually a fixed flexion deformity of the knee and the hip.

PATHOLOGY

Brockman had an opportunity of studying the morbid anatomy of a case of this type. He found that the musculature of the sole of the foot consisted of an undifferentiated mass there being no attempt at division into individual muscles. The tendon of the *tibialis posterior* was small and terminated in a fibrous mass which appeared to represent the navicular. The *tibialis anterior* was well developed and was inserted on the medial margin of the foot. The lateral edge of its tendon appeared to blend with a well marked sheet of fibrous tissue passing across the dorsum of the foot which Brockman took to be the tissue from which the tendons of the *extensor digitorum longus* should have developed there being no muscle tissue apparent in the situation of this muscle.

In Brockman's case there was also a flexion deformity of the knee. In operating on the knee he again found that the muscles and tendons were represented by a sheet of fibrous tissue containing here and there a few muscle fibres. It is clear therefore that his case was part of a generalized muscular disturbance although occasionally the condition may be confined to one or both feet.

2 The Osseous Type This type of clubfoot is associated with partial or complete absence of the tibia, the loss of support of the tibia resulting in an inversion deformity of the foot. Frequently this co exists with other abnormalities such as absence of the toes and failure of development of some of the bones of the tarsus.

Examination of the bones of the foot shows that in addition to alterations in position structural abnormalities are present the tibia

and the calcaneus being either completely or partially fused together to form a single bony mass.

MYODYSTROPHIA FŒTALIS

(Arthrogryposis Multiplex Congenita)

This is a congenital deformity affecting the extremities. In its usual form, there is unilateral or bilateral club foot and club hand, and these constitute the most obvious of the deformities. In each case, the error is notable on account of the rigidity of the parts, it being impossible often to obtain any degree of movement at the affected joints.

When the condition affects the lower limbs, there are also present contractures of the knee and the hip, which is often the site of a congenital dislocation of the hip (p. 20). As in the foot and hand, the hip deformity is gross and intractable, and the muscular activity of the limb is restricted completely or to a minimum.

ETIOLOGY

The disease displays a marked hereditary tendency, and a similar and comparable condition in lambs has been shown by Fraser Roberts to be transmissible as a Mendelian recessive characteristic.

Middleton, in a complete and fascinating study of this condition, has shown that in each case there are found obvious changes in the muscles of the affected part. Thus a muscle appears as a mass of fibro-fatty material, containing at scattered intervals some remnant of muscle fibre which displays degenerative changes. Middleton attributes these changes to a process of intra-uterine muscular degeneration—myodystrophia—alike, at least in its pathological effects, to the muscular dystrophies of a later age period.

The characteristics of the individual lesions which arise in myodystrophia fœtalis have been recounted previously (See congenital dislocation of the hip, congenital genu recurvatum, congenital club-foot, etc.)

CONGENITAL HIGH SCAPULA

The name of Sprengel is often associated with this deformity, although he was not the first to describe it. It consists of an abnormally high and permanent elevation of the shoulder, and is frequently associated with other deformities, such as congenital scoliosis, absence of vertebrae, fusion of ribs, or cervical rib, i.e. errors in segmentation or position of the cervical spine. There is often also a midline cleft between the two occipital bones.

ETIOLOGY

This deformity is the result of imperfect descent of the shoulder girdle, which first appears as a cervical appendage, but which should

descend by the end of the third month to the level of the upper part of the thorax. The proper designation, therefore, should be underscended, or high, scapula.

Various explanations of this permanent arrest in the descent of the shoulder girdle have been suggested, but hitherto none has accounted satisfactorily for the gross abnormalities of vertebræ and ribs, nor for the development of a bridge of bone anchoring the scapula to the spine, all of which frequently co exist. Fairbank believes that the condition is a result of a faulty segmentation of the mesoblast in early foetal life, and Middleton in a recent article has followed out this suggestion and given what appears to be a more satisfactory explanation of the deformity and its associated defects. He found, in one of his cases, a band of muscle passing from the skull to the scapula and clavicle the dissection of which suggested that this band, by failing to grow, had caused the scapula to remain in an unduly high position, and by virtue of its pull upon the developing skull prevented the normal closure of the tectal plates to form the foramen magnum. The muscle consisted of masses of undeveloped muscle cells which had remained in the myoblastic stage, which should normally terminate about the third month. The myoblastosis of muscle, however, was not limited to the abnormal occipito scapular band, although most pronounced in that region. Middleton has suggested that in congenital high scapula there is a widespread deficiency in mesodermal development in the cervical region of the embryo, which results in irregular vertebral segmentation, and in muscular atrophy in the affected area of the limb bud. To this primary muscular change and consequent failure of growth the striking deformity of the shoulder may be attributed. He has pointed out, however, that since the irregularity in the cervical segmentation considerably precedes the muscular changes it cannot be the result of the muscular anomalies but must share with them a common cause.

PATHOLOGY

Changes are found in the bones and in the muscles.

The Bones. The scapula may be of normal shape, or may be broadened at the expense of its length. It lies at an unusually high level, and may be attached to the vertebral column or the occipital bone by a band of imperfect muscle tissue, or by fibrous tissue, or even by a bar of cartilage. This band represents the fibres of the trapezius and the levator scapulae. Among the associated errors in segmentation of the cervical spine are included hemivertebræ and wedging of the vertebræ, both of which produce congenital scoliosis. The atlas may be in two halves, one or both of which may be fused to the occipital condyles.

The Muscles. Constant alterations in the musculature of the shoulder girdle are found. The trapezius may be largely absent, the rhomboid and the levator scapulae muscles being represented by the

muscular fibro is or cartilaginous band which passes up to the vertebral column or the occipital bone. Occasionally, this anomalous band of tissue may be ossified in whole or in part.

CLINICAL FEATURES

The scapula on one or both sides is 1 to 4 inches higher than usual. It is also tilted forwards so that the shoulder appears to be displaced upwards and forwards. When the arm is raised the scapula does not move laterally, nor does its lower angle rotate when the arm is raised above the horizontal.



FIG. 23.—Congenital High Scapula
(Sprengel's Shoulder)

An example of the deformity in a boy 7 years old.

The deformity of the shoulders rather than any functional disability of the arm attracts the notice of parents and only occasionally is there weakness of or disinclination to use the limb. All movements of the arm are complete except abduction and elevation to the vertical position. The neck is frequently short in appearance, though the shortness is often more apparent than real, being caused or accentuated by the high position of the shoulder girdle. Torticollis is present in about 10 per cent of cases. Cranium bifidum and spina bifida are often present. The skull may show the type of cranium bifidum which is caused by an unclosed tectal plate and consequent prolongation of the foramen magnum backwards between the two

halves of the squamous occiput. Congenital kyphosis affecting the thoracic region is an almost invariable accompaniment of the deformity, whilst scoliosis is quite frequently present as well.

DIAGNOSIS

The X ray appearances are characteristic, the films showing the unduly high situation of the scapula. Other congenital defects in the neighbourhood may also be apparent.

PROGNOSIS

Even if operation is undertaken, prognosis is not very favourable. Published results indicate that while the mobility of the shoulder may be improved, asymmetry almost always persists.

TREATMENT

If a definite bridge of bone or fibrous tissue anchors the scapula to the spine, the bridge may be removed, and any shortened muscles tenotomized at the same time. The scapula is exposed by an incision running parallel to, and a little above, its spine. The suprascapular group of muscles is removed subperiosteally, the upper border of the bone identified, and the muscles attached to it also erased subperiosteally. The upper part of the scapula is now removed with bone forceps, and the remainder pushed down as far as possible. The bridge of bone on the upper part of the scapula is removed, the bony edges rounded off, and if necessary, covered with fascia. If the scapula cannot be mobilized completely, and there is a tendency to recurrence of the deformity, it is sometimes wise to suture the inferior angle of the scapula to one of the lower ribs in order to hold it in place. The author doubts the advisability of suggesting operation in this deformity as the results are disappointing.

CONGENITAL SHORT NECK

(Klippel Feil Syndrome Brevicollis)

Our knowledge of this condition dates from a paper by Klippel and Feil who, in 1912 described a case which has formed the basis of all subsequent work on this subject. It would appear to be an advanced stage of high scapula. The prominent features which are emphasized as being the essentials of this syndrome are

- (a) Short neck or absence of neck
- (b) Absence, or limitation, of movement of the head
- (c) Lowered hair line
- (d) Often there is an expressionless mongoloid type of face

The neck is frog like and so short that the individual may appear to have no neck at all—the type called by the French *les hommes sans cou*. Movement of the head is very slight or is practically absent, and movement of the facial muscles is sometimes limited as well. The trapezi are tense and produce a wing like appearance which has given rise to the name “congenital webbed neck.” There may be an added torticollis of muscular or bony origin. The posterior hair line of the scalp is so low that it reaches the upper part of the thoracic wall. Scoliosis, elevation of the scapula, and other congenital anomalies may be present.

Varying degrees of the deformity occur. In the slighter cases the cervical shortening is not marked to any great extent. The conditions found on X ray examination vary in an extraordinary way. In

the typical extreme case there is a fusion of the lower cervical vertebrae and usually the thoracic vertebrae, into a solid mass. Less extreme cases vary from simple atlanto occipital fusion to all possible combinations of fusions of different vertebrae. There is thus evident a considerable deformity of the cervical spine and usually numerical reduction of its component elements. Cervical spina bifida is usually present. As in other congenital defects, there are frequently associated defects in other parts of the body. Thus one case showed a supernumerary lobe of the lung, while in another there was a patent foramen ovale, and in another a cleft palate. Occasionally mental retardation is present. A few have shown functional impairment of the upper extremities suggestive of a common neurogenic origin.

The condition is evidently due to irregular segmentation of the spine in the early weeks of foetal life if the embryo is subjected to any injurious influence.

The importance of recognizing the condition lies, not in any hope of remedying the deformity, but in its differentiation from other conditions which present a somewhat similar appearance and are to some extent amenable to surgical treatment, namely, congenital torticollis and Pott's disease. The simpler congenital deformity of elevation of the scapula has also to be considered.

It would also appear desirable to investigate the cervical spine in all patients presenting Sprengel's deformity, since it is invariably one of the elements of the grosser Klippel Feil syndrome.

TREATMENT

Treatment as a general rule is not indicated, but in cases where there is an extensive fold of skin a plastic operation may produce marked improvement. Gilhes has described such a case.

CLEIDO CRANIAL DYSOSTOSIS

The syndrome known as Cleido Cranial Dysostosis and described by Marie and Fenton in 1897, is a relatively rare condition, of which the leading features are (1) aplasia of the clavicles, (2) exaggerated development of the transverse diameter of the cranium, (3) delay in closure of the fontanelles. Hereditary transmission is the rule. The condition affects both sexes equally, and may be transmitted by either father or mother, to either sons or daughters. Several cases are reported, however, in which neither a familial nor a hereditary history was discoverable.

Heineke distinguishes between the following varieties of congenital defect of the clavicle.

- 1 Where the ends of the bone are normal, but a pseud arthrotic gap filled with connective tissue exists between them.
- 2 Where there is a partial defect of one end, usually the acromial, its place being taken by fibrous tissue.

3. Where the whole clavicle is absent.

Where the scapula is absent in addition, the deformity must be regarded as an aplasia of the whole shoulder girdle rather than a dysostosis.

The deformities of the clavicles are always accompanied by variations in the muscles. The clavicular portion of the trapezius may be absent; there may be mal-development of the pectoralis major; the

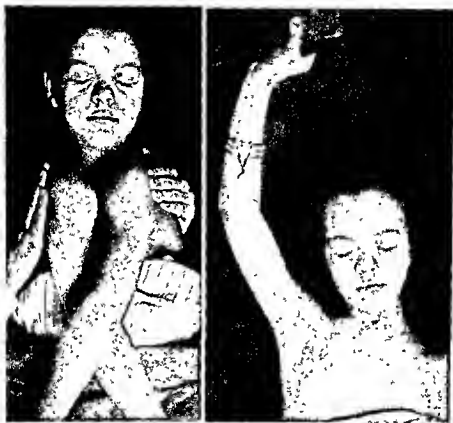


FIG. 26.—Cleido-cranial Dysostosis.

Note the approximation of the shoulders, and the excellent functions of the limbs.

clavicular portion of the deltoid may be deficient; or there may be a wide variation in the form of the sternomastoid.

Many other malformations have been reported in association with defective clavicles. Some of these are: brachiocephaly and dolicocephaly; malformations of the various sutures, fontanelles, and bones of the skull and face; disturbances of dentition; achondroplasia; variations in the small bones of the hands and feet; deformities of the thorax, spine, and pelvis; prolapse of the virginal uterus; inguinal hernia; and spina bifida.

ETIOLOGY

Little or nothing is known of the etiology of this condition. Steudler thinks it belongs to the class of intrinsic systemic deformities, arising during the first week of embryonic life. The condition affects the bones which are formed in membrane. Thus the vault of the skull may show membranous areas which persist throughout life. The clavicle itself is mainly formed in membrane. Its ends, however, are ossified from cartilage, and in this deformity the ossification of the ends usually proceeds as in the normal condition, so that the clavicle is represented as a flexible membranous rod with a portion of bone at either end. In Hemeke's other types, the error is evidently more extensive, and the normal ossification of the parts derived from cartilage is also interfered with.

CLINICAL FEATURES

The patient is usually brought to the surgeon on account of some accidentally discovered trouble with the shoulder. Sometimes an indefinite injury precedes, but more frequently no such history is obtained. Examination usually shows an apparently ununited fracture, or complete absence, of the clavicle, and the patient can usually approximate the tips of his shoulders to each other below the chin.

TREATMENT

If pain is present from the pressure of one or other of the ends, then removal of the part is indicated. As a rule there is little or no disability or discomfort and the abnormal mobility is not usually a hindrance.

CONGENITAL DISLOCATION OF THE SHOULDER

True congenital dislocation of the shoulder is very rare, but the term is, wrongly, applied to acquired dislocations occurring at or shortly after birth which are not so uncommon. The commonest forms of acquired dislocation are those arising from trauma at birth, or developing as a sequel to birth palsy. The true congenital form is not associated with difficult labour, and there is therefore no evidence of bruising at birth. It is often not discovered for some time.

The dislocation is invariably posterior, and subspinous. Greig, reviewing this condition, draws attention to Studer's observations on two cases in one family in which the deformity occurred. In each case the labour had been easy, the accoucheur had failed to recognize the deformity, but it had been noticed by the mother soon afterwards. The deformity was the same in both cases, viz. abduction at the shoulder, medial rotation of the arm, and slight flexion of the arm and forearm. Movement was limited, and the head of the humerus was palpable below the spine and behind the acromion. The glenoid could not be

felt the scapula was small and the acromion and coracoid were closely approximated. The electrical reaction of the muscles was normal.

Congenital dislocation of the shoulder has been described in association with congenital dislocation of the hip. In cases operated upon the head of the humerus has been found to be small and atrophied and resting on a facet on the posterior aspect of the glenoid fossa. Greig states that muscular action alone hardly seems a likely possibility. Uterine pressure alone seems equally unlikely, but the two together accompanied or not by some spasmodic contraction of a muscle or group of muscles seems to give a possible explanation. It seems not unlikely, however, that as in congenital dislocation of the hip an aplasia of the glenoid fossa may be the most potent factor in producing such a lesion. Those who have operated on the condition appear to have found no great difficulty in reducing the dislocation. Some cases have been reduced by manipulation alone. If this is successful then the arm must be splinted for a few weeks to keep it in position.

CERVICAL RIB

It is an old observation that numerical variations are common in the rib series of man. There may be an extra rib either in the cervical or in the lumbar region on one or both sides.

Galen and Vesalius were the first to describe a cervical rib in detail. It is a supernumerary rib which springs from one of the cervical vertebrae usually from the seventh, rarely from the sixth and very rarely from the fifth.

EMBRYOLOGY

Wood Jones attributes the formation of supernumerary ribs to a conflict between the developing nerve plexuses and ribs. In the higher forms of animal life the limb buds when they appear are in relation to several vertebral segments, the nerves from which grow into them. As the growth of the limb buds does not keep pace with the longitudinal growth of the vertebral column the course of the segmental nerves to the buds becomes more and more oblique. There then ensues a conflict between the obliquely running nerves and the developing costal processes of the cervical vertebra. The nerves much larger in proportion to the vertebrae and ribs of the embryo than to those of the fully developed animal impede the growth of the costal processes. The extent of growth of any cervical process is therefore determined by the extent of the resistance of the nerve in its path. Jones believes that when there is an accessory cervical rib—i.e. a hypertrophied cervical costal process—there has been a preceding anomaly in the nerve plexus. It is now well established that in addition to the normal arrangement two well marked variations may occur in the grouping of the brachial plexus. These are

1 The pre fixed plexus which receives a considerable part of the fourth cervical root, and only a small contribution from the first thoracic

2 The post-fixed plexus which receives no fibres from the fourth cervical but has a large first thoracic contribution and a reinforcement from the second thoracic

In association with the first type of plexus the costal process of the seventh cervical vertebra does not encounter its wonted resistance and therefore tends to be unusually well developed. With the post fixed plexus the costal process of the first thoracic vertebra is met by abnormal resistance and may remain rudimentary. Todd on the other hand is of opinion that the blood vessels are of equal importance in producing anomalies of the upper end of the thorax

ANATOMY

In 1869 Gruber of St Petersburg classified cervical ribs by dividing them into four groups

1 A rudimentary rib in which the costal process does not reach beyond the transverse process

2 A more pronounced type in which the cervical rib reaches

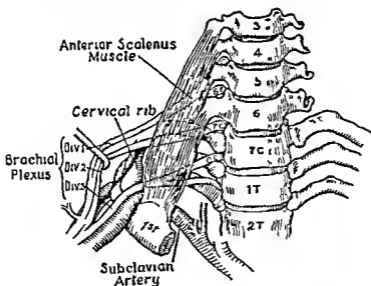


FIG. 1.—The Effect of the Scalenus Anterior Muscle on the Lower Cords.
(After Adson.)

beyond the transverse process and either has a free end or touches the first rib

3 An almost complete rib joined to the cartilage of the first rib by a distinct band of fibrous tissue or by the tip of its long body

4 A complete rib which possesses a true costal cartilage uniting with the cartilage of the first rib or with the sternum

A complete rib extends laterally from the seventh transverse process then turns forwards and downwards between the scalenus anterior and scalenus medius muscles to join the costal cartilage of the first rib. As it turns downwards the brachial plexus passes over it and on its downward course the subclavian artery arches backward and laterally across it. Usually the scalenus anterior acquires some attachment to the cervical rib and separates it from the subclavian vein. Above the vein and close to the rib the transverse scapular and transverse cervical branches of the thyreo cervical trunk pass across the root of the neck. Above and almost parallel to them is the posterior belly of the omohyoid muscle.

When the rib is incomplete the scalenus anterior is less likely to be attached to it. Murphy states that if the rib is long enough the space between the cervical and the first thoracic rib is occupied by intercostal muscles and by an intercostal vein and artery in exactly the same manner as in the thoracic intercostal spaces.

Not everyone with a cervical rib suffers from pressure on the nerve cords, indeed it is well known that some persons with well developed cervical ribs have no symptoms. It has been laid down as a rule by Lewis Jones that where a bony prominence can be felt with ease the brachial plexus is usually free from pressure. In these cases it is to be presumed that the pre fixation is considerable and that the plexus and the bony outgrowth have readjusted themselves at a higher level than normal.

The normal dropping back of the shoulder girdle and the upper extremity which occurs in adolescence is another important anatomical feature. In women the shoulder drops back farther than in men, and it is obvious that the greater the drop of the arm relative to the highest rib the greater will be the tension on the lowest cord of the plexus as it arches over that rib. It is also obvious that when drooping of the shoulder girdle has produced sufficient tension to cause the development of symptoms these would probably be relieved by elevation of the shoulder.

Incidence In reviewing 80,000 routine examinations at the Mayo Clinic for the five years ending in 1914, Henderson found 31 cases of cervical rib. The condition is bilateral in 67 to 80 per cent of all cases. Two cervical ribs on the same side are extremely rare but have been reported.

Cervical rib is found more often on the left side but according to Murphy, symptoms are more common on the right because of the greater use made of the right arm because the right brachial plexus is in closer connection with the corresponding rib than the left and because there is a greater drooping of the right shoulder in right-handed persons. Sargent reports that in his series of cases symptoms were usually present on the side of the smaller rib.

Authorities are agreed that the condition is more common in women than men. Childbirth, the greater susceptibility of women to the con-

ditions which precipitate symptoms—rapid loss of weight, chronic nervous exhaustion, and general ptosis—are important factors, as also is the greater drooping of the shoulder girdle in women.

SYMPTOMS AND SIGNS

Ætiology. Symptoms may occur at any age, the earliest being recorded by Stiles in a patient of 18 months. The average age is about 30 years. During childhood and adolescence there is a progressive descent of the shoulder girdle, which normally attains its final position in adult life. In many individuals, a further droop may result from acquired deformity, and, if a cervical rib is present, the persistence of this deformity places the lowest plexus trunk under conditions of abnormal tension. The elasticity of the nerve trunk permits slight repeated friction without damage, but the margin of safety is small, and friction neuritis easily initiated.

Adson and Coffey have pointed out the importance of the scalenus anterior muscle in the causation of symptoms. They were able to demonstrate the pressure on the nerve trunks of this muscle by making the patient elevate the chin, extend the neck, or rotate the head to the affected side, while taking a deep inspiration. This produced paresthesia over the distribution of the brachial plexus, and, frequently, obliteration of the radial pulse on the affected side. There is evidence that in some cases the scalenus medius, or a fascial band in the same plane may cause the symptoms, and in such cases these tight structures will also be divided. Adson attributes the pathological changes in the distal vessels, and particularly the cyanosis produced, to a disturbance of sympathetic innervation.

Symptoms of cervical rib may be grouped as sensory, motor, vasomotor and local.

1 The Sensory Symptoms. (*a*) *Subjective.* In many cases the patient complains of tingling in the hands and fingers, particularly in the finger tips. As a rule, these symptoms are unilateral, a point of importance in diagnosis. They are more frequently referred to either the ulnar or the radial side than to the whole hand.

Pain is also experienced, and is constant in its distribution. It is usually felt only in the forearm, hand, or fingers, and radiates chiefly in a downward direction. The pain may be sharp and lancinating and may be brought on by sudden rotation of the head or by a forceful, downward pull of the shoulder. Sometimes it is dull, aching, burning or boring in character, and frequently occurs late in the day after the patient has been working for a time. Especially is this so in the case of housewives, when it often begins after sweeping, washing, or dusting.

(*b*) *Objective.* In some cases there is no alteration in cutaneous sensibility, but as a rule sensibility is diminished or lost. This anæsthesia does not always strictly correspond in its distribution to the

areas supplied by the radial or ulnar nerves nor does it entirely coincide with a root supply.

2 The Motor Symptoms In the early stages there is steadily increasing weakness of the hand and inability to carry out finer movements.

Wilson describes two types of muscular involvement. The first of these called the median type is very frequent. There is early wasting of certain muscles of the thenar eminence viz the abductor pollicis and the opponens pollicis all the other thenar muscles including the flexor pollicis brevis being intact. The wasting may be slight or profound enough to render apparent the outline of the metacarpal bone of the thumb. The fact that only two of the three thenar muscles supplied by the median nerve are affected indicates that the nerve supply of the thenar muscles is derived from two sources—the eighth cervical and first thoracic segments.

The second type of muscular involvement is that corresponding to the ulnar distribution. Wasting of the interossei is present and in appearance the hand approximates to the main en griffe indicative of a lesion of the eighth cervical root. Occasionally only muscular cramp in the hands and fingers is complained of muscular atrophy being absent.

3 Vasomotor Symptoms Circulatory changes may produce a dusky coloration of the affected arm and hand associated with mild trophic changes in the tips of the fingers. Several cases have been reported where gangrene of one or more fingers has followed obliteration of either the radial or the ulnar artery or both. Diminution in the volume of the radial pulse is common. The pulse can be decreased or obliterated by making the patient elevate the chin or flex the head to the affected side during inspiration. Occasionally the subclavian artery may be seen pulsating above the clavicle and even aneurism of the subclavian artery has been noted. The presence of Horner's syndrome has been recorded due possibly to pressure or traction on the inferior cervical ganglion.

Todd has suggested that the vascular symptoms are due to the pressure of the rib upon that portion of the sympathetic which enters the arm by the lowest trunk of the plexus. Telford and Stopford have shown that the arrangement of the sympathetic fibres in the lowest trunk is not constant but that they occasionally form a separate bundle on the inferior aspect of the trunk. They are then in apposition with the rib and they may be exposed to friction or pressure. This bundle of sympathetic fibres is distributed along with the branches of the plexus to the peripheral vessels at varying levels and friction induces irritation with consequent spasm of the arterial wall. The persistent spasm must embarrass the vasa vasorum and lead to changes in the health of the vessel wall. Thrombosis and gangrene are secondary to those changes. That portion of the main arterial trunk (subclavian and axillary) which lies above the pectoralis major tendon is innervated

vated by a *peri-arterial plexus*, and not by branches from the cerebro-spinal nerves, so that it is not affected by cervical rib and remains open, healthy and pulsating.

Lewis and Pickering criticize the above theory. They believe that obliterative lesions of the distal limb arteries are due to injury of the subclavian artery between the articulation of the cervical and first thoracic ribs and the clavicle, which space may often be so narrow as to nip the artery. They suggest that this injury may be followed by thrombus formation and subsequent detachment of the thrombus, so obstructing the distal arteries. Aneurysm of the artery has been described, and Eden has tabulated forty-five published cases forming an impressive body of evidence in favour of the view that the vascular disturbances result from injury to the subclavian artery.

4. Local Symptoms. Not infrequently the patient complains of a dull ache or a dragging pain, at the root of the neck.

DIAGNOSIS

An abnormal transverse process of the seventh cervical vertebra can usually be demonstrated in an X-ray film. It is only by counting the number of vertebræ which lie inferior to the suspected supernumerary rib that the real nature of the case can be determined with certainty, as it is known that by no means all rudimentary ribs are derived from the seventh cervical vertebra, although clinically they are commonly classed as cervical ribs. Many of them are rudimentary first ribs.

The severity of the symptoms does not depend on the size of the bony projection. A small bony rib which might reasonably be considered little more than a large transverse process, may be so anchored down to the first rib by a firm fibrous band that the nerve is subjected to continuous and severe stretching. On the other hand, a large or even complete accessory bony rib may be present without causing inconvenience.

As similar symptoms are often present in patients who show little radiological evidence of an accessory rib, certain spinal diseases, such as syringomyelia, and progressive muscular atrophy, and also lesions of the ulnar nerve, must be considered in diagnosis.

In syringomyelia the thenar eminence may remain unaffected for some time.

In progressive muscular atrophy the thenar muscles are usually the first to be affected but the whole group is involved, whereas, in the case of cervical rib, selection is apparent. This dissociated palsy of certain of the thenar muscles is of considerable importance in diagnosis.

TREATMENT

Surgical treatment of the condition is indicated when the symptoms are sufficient to incapacitate the patient; and when there is evidence

of circulatory disturbance such as obliteration or reduction of the radial pulse on extending the neck or rotating the head. Where there is marked paræsthesia and the patient is of a neurotic type the advisability of operation should be discussed the decision being left to the patient.

If a cervical rib is discovered accidentally and is causing no symptoms surgical treatment is not indicated. In these cases it is well for psychological reasons to refrain from informing the patient of the condition.

In many cases where the symptoms are slight improvement results from the development of the trapezius and the levator scapulae muscles. Bracing up the shoulders relieves the constant strain on the nerve trunk as it crosses the abnormal rib. This improvement is particularly seen in cases where there has been a recent illness with loss of muscular power. In some cases it may be advisable to change the occupation to one in which less strain is thrown on the affected arm.

In cases with severe symptoms operation should be recommended as the condition can be cured by removal of the rib and the fibrous band which is causing the abnormal pressure. Pain and circulatory disturbance are the principal indications for operation and when the condition has gone as far as muscular atrophy operation is unlikely to be of benefit.

The Operation The operation may be performed through an anterior or a posterior incision the former being preferable.

A sandbag is placed under the shoulders and the head turned well to the opposite side. A long straight oblique incision is made from just above the sterno-clavicular joint outwards and upwards at an angle of 30 degrees with the clavicle for about 5 inches. The trapezius and the spinal accessory nerve are retracted backwards after resecting the descending superficial cervical nerve. The omohyoid muscle may be excised. The external jugular vein and the posterior border of the sternomastoid are freed and retracted inward. The transverse cervical artery is ligated and divided as it crosses the brachial plexus. The plexus is exposed along the anterior surface of the scalenus medius muscle between the lateral border of the scalenus anterior and the clavicle. The lower part of the scalenus medius muscle is reached by mobilizing the plexus and retracting it downward and inward. The supra-scapular nerve is found arising from the lateral border of the upper trunk of the plexus. The long thoracic nerve is carefully protected from injury in freeing the plexus from the scalenus medius. It lies behind the lateral portion of the plexus between it and the muscle. The two upper roots pierce the muscle. The lowest crosses in front of it and the trunk of the nerve after crossing the first digitation of the serratus anterior descends behind the clavicle to reach the axilla. The serratus anterior which occupies the floor of the outer angle of the wound is recognized by the transverse direction of its fibres.

Should the rib be not well developed, it will be found by dividing the fibres of the scalenus medius above the first thoracic rib. Stretching between the two ribs is a thin sheet of muscle fibres the homologues of the thoracic intercostal muscles. They are divided close to the cervical rib so as not to injure the pleura and what corresponds to Sihson's fascia is carefully divided along its inner border. Before this can be done the lowest trunk of the plexus which arches over the cervical rib must be freed and retracted downward and inward. Before freeing the rib carefully from the cervical pleura it is divided at its junction with the tip of the transverse process and the seventh cervical vertebra.

Frequently the anterior extremity of the rib is found to extend

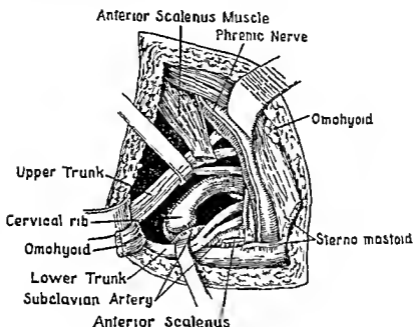


FIG. 28—Adson's Operation

The scalenus anterior is divided near its insertion and the pressure on the plexus removed. (After Adson.)

farther forward and to join the first rib opposite the scalene tubercle, the scalenus anterior being inserted into both structures. In such cases the subclavian artery lies in front of the articulation. In dealing with this condition the third part of the subclavian artery is exposed at the lower and inner angle of the wound, freed from its fascial sheath, and retracted downward and inward. This allows of the detachment of the insertion of the scalenus anterior from the tip of the cervical rib and also of the removal of the outgrowth of bone which is sometimes thrown out to meet the cervical rib.

If the rib is rudimentary it is completely embedded in the substance of the scalenus medius. In such cases a fibrous band frequently

extends downward and forward like a bow string to be attached to the first rib at or distal to the scalene tubercle. As the first dorsal nerve arches over this band on its way to join the eighth cervical nerve it is important to remove the band along with the rudimentary rib. The best access to it is obtained by opening up the interval between the upper and middle trunks of the plexus by small goitre retractors.

The operation is completed by suturing the cervical fascia with catgut and the skin with fine silkworm gut and clips. No drain is inserted.

Adson removes the supernumerary rib by an interplexar route as depicted in Fig. 28.

Adson and Coffey now believe that the removal of the rib is unnecessary inasmuch as the subclavian artery and the brachial plexus are immediately relieved from pressure and irritation by detaching the scalenus anterior from its insertion. They have operated on four patients in each case dividing the tendinous attachment of the scalenus anterior without removing the cervical rib. They state that symptoms were completely relieved. The paper of Adson and Coffey presents a very convincing argument and the operation is probably sufficient in a number of cases but in many the rib still has to be removed to be certain of cure.

THE SCALENUS SYNDROME

The term scalenus syndrome has been applied to the condition in which the nervous and vascular complications usually associated with

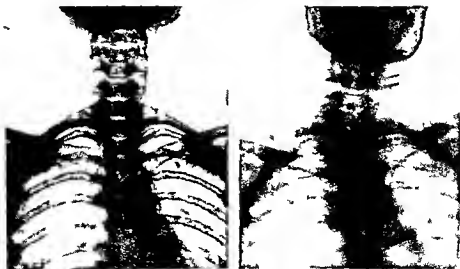


FIG. 29.—B lateral Cervical R1 with Lateral Synptoms

The first rib appeared to be equal in pressure also so part of it was removed.

cervical rib occur in the absence of any demonstrable bony abnormality at the root of the neck. It has long been known that compression of the brachial plexus and of the subclavian artery may be produced by the first thoracic rib, and the condition has been relieved by resection of the offending rib. Many of these cases are diagnosed as neuritis, neuralgia, progressive muscular atrophy, etc. Some are traumatic in origin, symptoms developing after an injury which causes sagging of the shoulder. In most cases, however they develop spontaneously, sometimes during adolescence. They are often initiated or aggravated by exertion, or by drooping of the shoulder from carrying heavy objects or wearing a heavy coat and are relieved by elevating the arm.

The symptoms, as in most cases of cervical rib are chiefly referred to the distribution of the lower trunk of the brachial plexus, the eighth cervical and first thoracic roots. There is pain or sensory disturbance along the medial aspect of the arm and forearm, and in the fourth and fifth fingers, and atrophy of the hand muscles. Common symptoms are coldness of the hand, sometimes associated with slight dusky skin, weakness in the hand and pain in the arm, trophic sores were noted in two of Stopford's cases. There are cases too, where the chief pain is elsewhere than in the area of the brachial plexus, e.g. in the middle of the clavicle. Stopford points out that in the objective sensory disturbances the loss of protopathic sensibility is greater than that of epicritic, and suggests that this dissociation is characteristic of nerve compression. Hitherto the condition has been relieved by resection of the dorsal rib, but in the opinion of Ochsner Gage and De Bakey this formidable operation is unnecessary since decompression of the plexus and artery can be obtained just as effectively and far more simply by excision or even division of the lower end of the scalenus anterior muscle and often the scalenus medius as well. This operation was first recommended by Adson and Coffey for the more usual cervical rib syndrome. Division of the muscle allows the plexus and artery to slip forwards and downwards, and anyone familiar with the operation will testify to the immediate and remote success of the decompression in all straightforward cases.

In certain cases the division of the muscle may not be enough to relieve the pressure on the plexus owing to the position of the rib—cervical or first—and in these cases the rib must also be removed.

The scalenus anticus muscle is supplied by the seventh cervical nerve, and it is said that any painful condition in the area supplied by the third to the eighth cervical roots may set up a reflex stimulation of the nerve resulting in spasm of the muscle. This further irritates the roots and sets up a vicious circle. Freiburg says that in certain circumstances any lesion involving the cervical spine or shoulder girdle may be the exciting factor causing the syndrome. Ochsner Gage and De Bakey indeed found at operation that the scalenus anticus was hypertrophied, spastic and fibrotic and were of the opinion that this was due to such reflex irritation.

CONGENITAL WRY-NECK

(Torticollis)

This is a deformity characterized by lateral inclination of the head towards the shoulder, accompanied by torsion of the neck and deviation of the face. It is caused by unilateral contracture of the sterno mastoid, with secondary shortening of the fasciæ and the other muscles of that side of the neck.

ETIOLOGY

Many theories have been advanced to explain the development of torticollis. It is claimed by some that there is justification for the hereditary theory, because cases with co existing congenital deformities, such as club foot or congenital dislocation of the hip, have been described.

Nove Josseland and Vianny think it is ischæmic in origin. They state that the middle part of the sterno mastoid muscle is supplied by an 'end artery'—a branch of the superior thyroid—and they have noted that in every case of wry neck the lumen of the sterno mastoid artery has been obliterated at the anterior border of the muscle.

It is generally held that trauma is the primary cause of this deformity. The usual belief is that during labour a temporary acute obstruction of the veins of the muscle occurs, and that this is rendered permanent by patchy intravascular clotting in the obstructed venous tree. In the early months of life this clotting is evidenced by the development of the sterno mastoid tumour of infancy. The tumour eventually disappears its place being taken by fibrous tissue which later contracts. The mechanism, therefore is very similar to that which produces the so called ischæmic contracture of the flexor muscles of the forearm (Volkmann's contracture).

CLINICAL FEATURES

The condition first becomes evident in the first few months of life when the mother notices an elongated swelling in the lower half of the sterno mastoid muscle. This swelling is at first tender, and the child cries bitterly if it is palpated, or if the muscle is stretched in any way. Gradually the swelling and the tenderness subside, but by the end of the first year of life it is noticed that the muscle is tense. This tenseness is due to the development in the substance of the muscle of a band of fibrous tissue which, by a slow but progressive contraction, pulls the head into the characteristic attitude, so that the ear on the affected side appears to be pulled down towards the sterno clavicular joint of the same side, while the face is rotated towards the opposite side. If the deformity is not corrected, a gradual atrophy of the face on the affected side develops and becomes increasingly

evident with the growth of the child. As growth continues, changes take place in other tissues, all the soft parts on the affected side undergo adaptive shortening while the bones of the cervical and upper thoracic spine acquire a fixed scoliotic deformity.

PATHOLOGY

A sterno mastoid tumour appears about two or three weeks after birth as a spindle shaped swelling occupying the position of one sterno-mastoid muscle. It may affect only the sternal head but frequently both heads are implicated. The tumour gradually becomes absorbed and finally disappears in from four to six months after birth. On microscopical examination it is found to consist of young cellular fibrous tissue containing here and there remnants of the original muscle fibres which are seen to be undergoing degeneration.

At the end of about a year changes hitherto confined to the sterno-mastoid muscle become evident in other structures in the neck. The muscle has now been reduced to fibrous tissue which has contracted and there is also some thickening and contraction of the deep cervical fascia and of the scalenus anterior and medius. The vessels on this side of the neck likewise become shortened in the late stages of the condition and are smaller in calibre.

The majority of cases show in their later stages a well marked asymmetry of the face which on the affected side becomes shorter from above downwards and wider from side to side. In addition on the affected side the frontal eminence is flattened while there is a well marked protrusion of the occipital region on that side. The vault of the skull is thrown backwards on the affected side and forwards on the opposite side giving rise to a deformity which is comparable to that seen in the thorax in cases of thoracic scoliosis and hence the name scoliosis capitis is sometimes and quite accurately applied to it. Occasionally an exostosis appears on the clavicle at the site of attachment of the clavicular head of the sterno-mastoid.

DIAGNOSIS

The recognition of congenital wry neck should theoretically, present no difficulty but some cases are obscure. Every case should be X rayed to exclude any vertebral anomaly which may be the primary error.

There is often a history of difficult birth although cases have been reported after a Caesarean section. The early fusiform swelling may have escaped notice but the later cord like contraction of the sterno-mastoid is characteristic.

TREATMENT

The treatment should be begun at an early stage, as the development of the deformity may thus be arrested in mild cases. It is

doubtful whether it is wise to manipulate and stretch the sterno mastoid muscle while the tumour is tender. In these cases it may be better to operate as soon as the child is strong enough say at the age of a month and to excise the tumour. The cause of the condition is thus removed and further changes are prevented.

In mild cases however manipulation and exercises are sufficient. The head having been grasped by the hand is moved into a position in which the deformity is over corrected the object being to stretch the affected sterno mastoid. The manipulation must be performed



FIG. 30—Congenital Wry Neck.

Before and after open division of the shortened structure.

gently. If this is carried out daily there will probably be little or no evidence of contracture at the end of a few months.

When the child is not seen until the age of 2 or 3 years operation is usually indicated for at that date manipulation is not likely to stretch the fibrous cord which replaces the muscle. Subcutaneous tenotomy is not advised as it is impossible to ensure that all the shortened structures will be divided and there is a danger of injuring the great vessels at the root of the neck.

These objections are not applicable to the open operation. It can be performed through a comparatively short incision so that the scar is insignificant. The operation is carried out under general anaesthesia the head being laid over a sandbag so that the shortened muscle is rendered prominent. An incision $1\frac{1}{2}$ inches in length is made $\frac{1}{2}$ inch

above and parallel to the clavicle, with its centre over the attachment of the affected muscle. In making the incision the skin is pulled down over the clavicle so that there is no risk of injuring the vessels at the root of the neck. The muscular heads are defined and a flat dissector having



FIG. 31.—Congenital Wry Neck.
The asymmetry of the face is characteristic.

been slipped beneath their deep surfaces each head is divided. When the muscle has retracted the deep cervical fascia is divided and if necessary the carotid sheath and the scalenus anterior. During the operation the head is gradually manipulated into the correct position in order to bring any shortened structures into prominence. The wound is closed without drainage by means of fine interrupted horse hair sutures. After the dressing is applied the head may be placed in an overcorrected position and retained there by means of a bandage or by a special apparatus.

The after treatment which is of great importance should be continued for about six

months. It consists of active and passive movements to prevent any recurrence of the deformity.

When it is desired to avoid a visible scar a muscle slide operation may be carried out as advocated by Lange. An incision is made over the origin of the sterno-mastoid from the mastoid process, this lies entirely in the hairy scalp. The muscle is erased from the mastoid process and from the superior curved line of the occipital bone. The operation is inadvisable where more than 1 inch of lengthening is required as greater mobilization may damage the spinal accessory nerve.

OTHER FORMS OF WRY NECK

Spasmodic Wry neck

The spasmodic type of wry neck occurs most commonly in adults and is obvious as soon as the patient is examined. Clonic contractions of certain muscles produce jerking motions of the head, which is suddenly and violently pulled over to one side while the face is rotated towards the opposite side. The greater the attention paid to the patient the more violent do the spasms become. The sterno-mastoid and the trapezius on one side and the posterior rotators of

the opposite side act together so that the result is a typical torticollis. At first the spasms may be controlled by the patient but later they are quite involuntary and indeed may spread to the facial muscles the muscles of the mouth and even to those of the shoulder.

ETIOLOGY

The question of etiology is interesting though rather mysterious though long considered a *neurosis* it is now believed to be an expression of some lesion of the basal ganglia. There are various types and Critchley conveniently relegates them into four groups.

(1) *Psychogenic cases*. A group where the head movement is a habit spasm or tic and usually found in younger patients.

(2) Following epidemic encephalitis and with or without a Parkinson syndrome.

(3) As a part of a widespread striatal syndrome it may be seen in progressive chorea athetosis or other affections of the basal ganglia.

(4) The pre senile progressive cases occur in middle or later life and form the largest group.

Ocular torticollis is recognized by the presence of abnormal movements of the eyeballs.

TREATMENT

Sedative drugs and re-educative exercises should be tried while fixation of the head and neck in a poroplastic jacket sometimes brings a considerable degree of relief. Surgical measures are carried out in aggravated cases and consist of resection of the spinal accessory nerve on one side and of the posterior primary divisions of the first three cervical nerves on the other. This has given considerable benefit in many cases the results being better than those following division of the affected muscles. The author does not advocate operative measures as the results are disappointing.

The Operation. Dandy advocates resection of the sensory and motor roots of the first second and third cervical nerves through a high cervical laminectomy in which the laminae of the upper three vertebrae are removed. He uses a median vertical incision. The spinal accessory nerves are divided intraspinally at the level of the foramen magnum only in order to obtain better exposure of the first cervical motor branch. When this part of the operation is concluded the patient is turned on his back the spinal accessory nerves are then exposed and divided through two small incisions in the neck and the central ends doubled back and sutured in this position to prevent regeneration. The extra spinal resection is added lest some of the anterior filaments escape in the intra spinal operation.

Other forms of wry neck demand only brief notice. The *acute form* occurs during some infection of the neck such as infected glands. The *traumatic form* follows injury which has resulted in the formation of fibrous tissue with subsequent shortening. A *paralytic form* may

develop as a result of division of the spinal accessory nerve during the operation for tuberculous cervical glands

CONGENITAL RADIO ULNAR SYNOSTOSIS

In congenital radio ulnar synostosis one or both forearms are fixed at birth in a position midway between pronation and supination as a result of fusion of the proximal ends of the radius and ulna. In some cases the condition is hereditary and it is equally common in both sexes.

MORBID ANATOMY

Wilkie has described two different lesions to which the term radio-ulnar synostosis may be applied though it is probable that the second type is not a true failure of separation of the upper ends of the forearm bones.

In the *true congenital radio ulnar synostosis* the upper end of the radius is imperfectly formed being fused to the ulna for a distance of several centimetres. The bony union is of an intimate nature and there is no compact layer intervening between the spongiosa of the radius and that of the ulna. The head of the radius may be fairly complete and fused to the ulna or may be absent. This 'headless' type is sometimes classified as a separate variety. The shaft of the radius arches forwards more than usual and is longer and stouter than that of the ulna suggesting that there has been either some arrest in the growth of the ulna or stimulation in growth of the radius. The lower ends of the bones are almost invariably separate although Appraille has observed synostosis of the distal ends as well, while Melchior has reported a co-existing Madelung's deformity. Primary synostosis is usually bilateral in over 80 per cent of the recorded cases both forearms have been affected.

In the *second type* there is a congenital dislocation of the head of the radius and the radius and ulna are fused at some point a short way distal to their upper extremities usually in the region of the coronoid. The dislocation may be either backward or forward more frequently backward. In backward dislocations the point of fusion of the two bones is at a lower level on the shaft but it is never so extensive or intimate as in a primary synostosis. The radius is relatively longer and stouter than the ulna but shows the same curvature as in the primary type.

ETIOLOGY

Congenital radio ulnar synostosis is essentially an arrest of development. The radius and ulna develop from a single mass of mesoderm as a pair of separate cartilaginous rods. From about the fifth week the volar aspect of the developing arm is applied to the trunk so that the radial and ulnar cartilaginous rods are in a position midway

CONGENITAL RADIO ULNAR SYNOSTOSIS

between pronation and supination. If the normal separation into distal ends does not occur at the upper part of the developing bones,

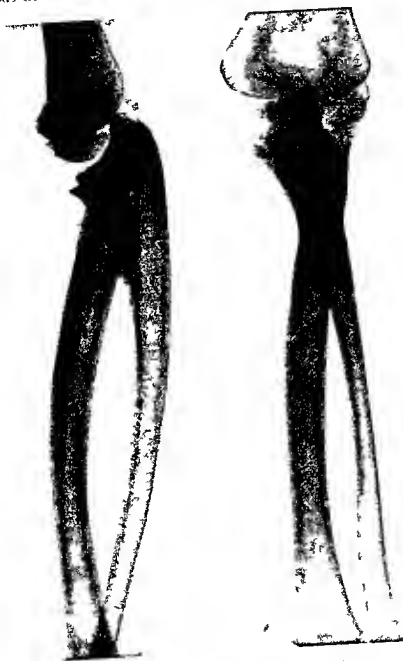


FIG. 3 —Congenital Supra or Radio-ulnar Synostosis.

The radiographic appearance of an example of the disease in a boy 8 years old.

or if chondrification and later ossification extends across the interosseous space filled interval between their upper ends a congenital radio-ulnar synostosis develops.

Hamilton has suggested that the deformity represents a partial reversion to one of the lower types of vertebrate forelimbs, since fusion of the radius and ulna is normally found in bats, camels, and some ungulates.

The type of synostosis associated with dislocation of the radial head is the result of some factor which operates at a later period of foetal life than in the case of the true synostosis. Wilkie believes that in some cases the synostosis may develop after birth, when, owing to increased movement, the periosteum of the two bones is irritated and possibly lacerated at the points where they lie in contact. New bone is, in consequence, laid down. In a case which he reported, the abnormality had not been noted until the child was 5 years old.

CLINICAL FEATURES

The main feature is fixation of the forearm in a position of mid-pronation. Movements of the elbow joint are usually free although extension may be limited. Wrist movements are often unduly free. There is no movement of the radius on the ulna, however, and there appears to be firm osseous union between the bones.

In a unilateral case the affected forearm is thinner than its neighbour, and has a curious twisted appearance, due to an alteration in the axis of the principal groups of muscles. At the point normally occupied by the head of the radius there may be a well marked sulcus, owing to the head being displaced backwards or forwards, or being imperfectly developed. The limitation of movement in the forearm is to some extent compensated for by rotation of the humerus, but the palm can never be fully supinated. The functional disability is therefore considerable although there may be little or no complaint, since the normal use of the hand has never been experienced.

TREATMENT

At first sight, it seems obvious that an operation is indicated. Wilkie however points out that the bony bridge is only part of the deformity, and that the soft tissues are not normally developed. He therefore doubts whether surgical intervention should ever be undertaken, an opinion with which the author is in entire agreement. In support of this, it is to be noted that the recorded results of operation are disappointing. In the type associated with dislocation of the head of the radius where the soft parts are more normal, the prospect of helpful intervention is more hopeful, but, in any case, prognosis should be guarded.

Operation. An incision is made over the synostosis and the bridge of bone excised. A layer of muscle, fascia or fat is then inserted between the radius and the ulna.

Fraser suggests the removal of the radial head along with the intervening bridge of bone, through an incision along the subcutaneous surface of the ulna. The route is thereafter a subperiosteal one, to-

wards the radial border of the ulna and thence to the bridge of bone. By this means all possibility of injuring the radial nerve is avoided.

CONGENITAL ABSENCE OF THE RADIUS

Absence of the radius is a rare developmental error but important because it is the commonest cause of club hand in which the hand is permanently deviated from the normal axis of the forearm. In rather less than half the cases the deformity is bilateral while over 40 per cent of cases are found amongst male children. The condition is sometimes hereditary it frequently co-exists with other forms of congenital anomaly notably harelip, cleft palate and certain forms of congenital club foot.

ETIOLOGY

The actual etiology is unknown beyond the fact that it arises at an early stage in the development of the limb bud. Its association with other developmental errors would suggest that the cause is to be found in some inherent abnormality in the developing mesoderm which should form the forearm bones. Whether the abnormality is the result of disease of some inflammatory process or of a nutritional error it is not as yet possible to say.

PATHOLOGY

Usually the whole radius is absent but occasionally when the defect is only partial a small portion of it remains generally at the upper end. When a small fragment of radius is present the ulna may be fused to it giving rise to a form of radio-ulnar synostosis. The ulna which may attain a considerable size in many cases is short thick and curved and the concavity of its curvature is nearly always directed towards the radial side of the forearm.

The carpus often shows associated abnormalities amongst which may be noted absence of the scaphoid or fusion of that bone with neighbouring carpal bones. More rarely the lunate is absent.

When the radius is totally absent the biceps is usually inserted into the lacertus fibrosus though in some cases the muscle is either completely absent or fused with the brachialis anterior or the coraco



FIG. 33.—Bilateral Congenital Absence of the Radius and Ulna.

The boy was well and able to play games with his fellows and in spite of a bilateral club foot of slight degree plays football.

brachiahs The brachio radialis is absent in about half the number of cases and when it is present it is usually short and stout and appears to be a continuation of the short head of the biceps. Occasionally it is continuous with the extensor carpi radialis longus and the two may be inserted into the ulna. The extensor carpi radialis longus and brevis are frequently absent or fused with the extensor digitorum communis while the extensor pollicis longus may also be lacking or fused with neighbouring tissues. The flexor pollicis longus



FIG. 34—Congenital Absence of Radius, right side.
Absence of both humeri.

and the pronator quadratus are rarely present. The radial nerve usually terminates at the elbow and there is often no radial artery.

CLINICAL FEATURES

Generally the affected arm shows some degree of atrophy but this is most marked in the forearm which is invariably short, stubby and bowed with a posterior convexity. The hand is small and atrophic. Further it is deviated to the radial side and slightly palmar flexed—radio palmar club hand. The thumb is occasionally absent, but despite these deformities the limb may retain a surprisingly good function although grasping power is usually impaired.

TREATMENT

The treatment depends to some extent on the symptoms for which the patient has sought advice. Amongst these are the unsightly nature of the deformity, weakness and inability to use the arm, limitation of certain movements, such as dorsiflexion, and, in younger patients, the retarded development of the whole arm.

The majority of surgeons are pessimistic in their outlook towards this deformity, even with treatment. Indeed, certain observers hold that the condition is not amenable to any treatment, since the anatomy of the arm is so profoundly disturbed. Certain operative methods, however, have been described.

Methods of Operation. (Fig. 35)

(1) *Feyer's Operation* Feyer performed an osteotomy of the ulna, and then gradually stretched, by adhesive plaster, the contracted tissue

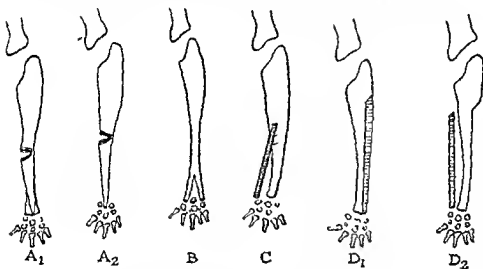


FIG. 35—Congenital Absence of the Radius.

Diagrammatic review of the operative treatment (After Kato)

- A₁ and A₂ Osteotomy of ulna and carpal pegging.
- B Bifurcation of ulna and carpal resection.
- C Tibial Graft from ulna to carpus.
- D₁ and D₂ Formation of new radius from the thickened ulna.

on the radial side of the forearm. Some weeks afterwards, the lower end of the ulna, sharpened by removing the styloid process, was inserted into a gap in the carpus, made by removing the lunate and capitate.

(2) *Bardenheuer's Operation* The distal end of the ulna is split longitudinally to form a radial and an ulnar portion. The carpal bones are allowed to slide up between the separated ends, which are then secured to the carpus on each side by the insertion of small ivory pegs.

(3) *Albee's Operation* Albee takes a small graft from the tibia and mortises it into the ulna, about the middle of that bone. The

lower end is then inserted into a specially prepared bed on the radial side of the dorsum of the carpus

(4) *Ryerson's Operation* Ryerson removes from the posterior surface of the ulna a graft which he implants in the situation normally occupied by the radius. The graft thus lies deep to the extensors of the hand the muscles and fascia being firmly sutured over it.

The last two methods are satisfactory so long as absorption of the graft does not take place.

(5) An operation suggested by W. V. Anderson and carried out with some measure of success by the author is based on a McMurray osteotomy of the hip. An oblique osteotomy is done on the ulna starting from above on the inner side and sloping downwards and outwards. The outer pointed end of the upper fragment is inserted into a previously osteotomized groove in the carpus. The result is good in correcting the deformity with maximum function but it is by no means easy to get the correct position in the carpus.

MADLLUNG'S DEFORMITY

(Congenital Subluxation of the Wrist)

Despite its name this deformity is probably not a true congenital one but due to some nutritional disorder to occupational strain or



FIG. 36.—Congenital Dislocation of both Ulnae

even to severe injury. Gibson classifies inferior ulnar dislocations of which Madelung's deformity is a type as follows:

- 1 With fracture
- 2 Without fracture
 - (a) Congenital (Madelung's)
 - (b) Acquired—Traumatic

Pathological

Jones and Lovett describe the condition as an occupational deformity following rotatory strain of the wrist. It is often found in char women.

The inferior radio ulnar joint depends for its strength on its ligaments the most important of which is the triangular disc of fibro cartilage fixed by its apex to the styloid process of the ulna and by its base to the distal edge of the ulnar notch of the radius. If this disc or its attachment is torn dislocation of the joint may result. The displacement consists of a forward luxation of the radius which carries with it the whole of the carpus and hand. The head of the ulna remains in its normal position though its undue prominence may suggest that it has been displaced backwards. Not infrequently the condition is bilateral.

CLINICAL FEATURES

The wrist appears enlarged and dorsal flexion of the hand is impaired. In severe cases pronation and supination are limited. The wrist is loose, insecure and irritable. In long standing cases the lower extremity of the radius is bent or curved forward.

Pressure on the ulna reduces it into line with the radius but the deformity recurs immediately the pressure is released owing to the laxity of the ligaments of the lower radio ulnar joint.



FIG. 37.—Bilateral Congenital Dislocation of the Ulna.

TREATMENT

In recent or acute cases dorsiflexion of the wrist maintained by a short plaster case and with a pressure pad over the prominent head of the ulna offers the best prospect of relief. The plaster should not interfere with the movements at the metacarpo-phalangeal joints.

In cases of longer standing operation is indicated and may be directed either to the ligaments or to the bones. Gibson points out that in the traumatic cases the torn triangular fibro cartilage is the key to the situation. He stitches this into place and puts the hand in a position of dorsiflexion and full pronation. This position is main-

tained by plaster for about six weeks. Gibson found the swelling to consist of the extensor tendon pushed dorsally through a tear in the deep fascia by the head of the ulna. The dorsal route of exposure gives excellent access.

Osteotomy of the lower end of the radius is recommended by some, the articular surface being rotated backwards into its normal position and the correction maintained by a plaster cast.

Henry Milch has described a new operation for the recurrent types

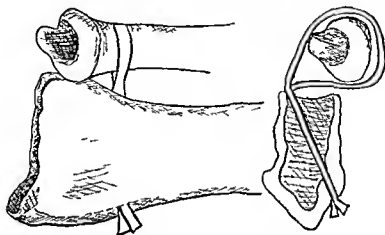


FIG. 38—Operation for Recurrent Dislocation of Ulna

of ulnar dislocation. A strip of fascia is passed around the lower end of the ulna, and then both ends of the fascia are carried through a drill hole in the radius running from the posterior and ulnar aspect forward and laterally to penetrate the outer radial cortex about $3\frac{1}{2}$ centimetres above the radial styloid. He suggests that the anterior and posterior radio ulnar ligaments should be plicated at the same time.

Darrach advocates the simpler operation of subperiosteal resection of the lower end of the ulna, and this gives as satisfactory a result as the more elaborate procedures.

SYNDACTYLISM

Syndactylism—web fingers or web toes—is a congenital anomaly in which two or more digits of the hand or foot are bound together. The defect is produced by an arrest of development before the fingers have become completely separated from one another. As the thumb is differentiated as early as the seventeenth day, it is rarely affected. The tissue connecting the two fingers may vary from a thin diaphragm of skin and subcutaneous tissue to a fusion which includes the bone to a greater or less degree, and in some cases even the adjacent finger nails may coalesce. In mild cases its only importance lies in the cosmetic aspect,

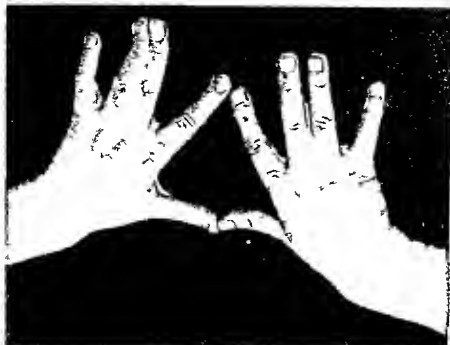


FIG 39—Syndactylism of Fingers
Complete degree on left side

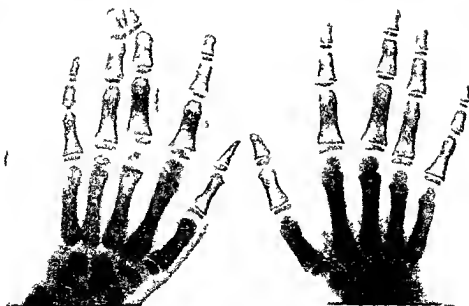


FIG 40—Syndactylism
The distal phalanges are fused.

but when several fingers are involved there may be serious impairment of function of the hand

TREATMENT

Operation should be postponed until the patient is from five to twelve years old, unless there is some special indication, such as in

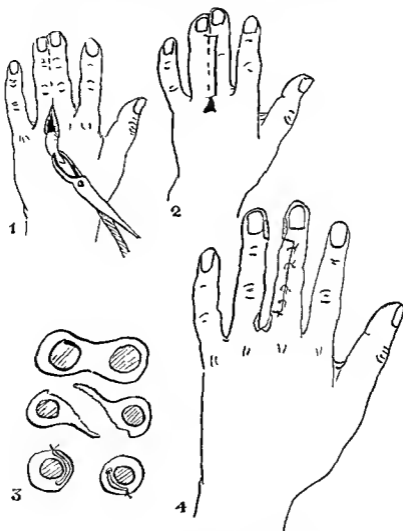


FIG. 41—Operation for Syndactylism

- (1) 1st Stage The web of the finger is reconstructed
- (2) 2nd Stage Anterior and posterior flaps of skin made to cover the contiguous surfaces of the fingers
- (3) Section showing the mode of fixation of flaps
- (4) 3rd Stage The flaps are sutured into position so covering the fingers

creasing deformity of the finger, for earlier interference. The treatment varies according to the width of the web. If wide, the repair is easy and the results good, but if the fingers are lying in very close

contact, with only a narrow web, the outlook is not good, and it is advisable in such cases to avoid interference

The operation is done in two stages. At the first stage a U shaped flap taken from the dorsum of the hand is turned between the roots of the fingers. This flap is turned back on the dorsum and the proximal part of the web divided. The dorsal flap is then pulled through and sutured to the anterior aspect of the root of the finger. The gap between

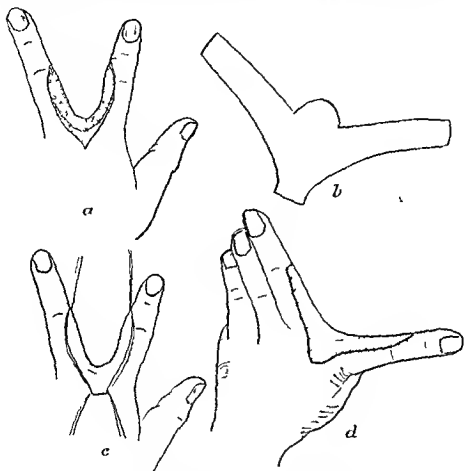


FIG. 42.—Full thickness Skin Graft for Web fingers
Stages of Operation described

the adjoining aspects of the two fingers is kept open by means of a small glass rod inserted into the aperture and secured in place by a dressing. The rod should remain until the channel heals by granulation tissue, thus generally takes five or six weeks.

At the end of that time the operation devised by Didot may be carried out. An incision is made along the middle of the dorsum of one finger, and along the middle of the palmar aspect of the other, the two flaps raised, and the fingers separated. The adjoining aspects are then covered by the anterior and posterior flaps respectively.

The operation of Didot, except in very favourable cases may be followed by finger contractures and with the introduction of the free full thickness skin graft, has now a very limited field. In cases where the result is in any way doubtful skin grafting should be preferred.

The graft operation as described by Kanavel avoids scars running across the creases of the finger, but great care must be taken not to injure the digital nerves and vessels. If more than one interdigital cleft is webbed only one web is dealt with at a sitting, since the



FIG. 43.—Dystrophy of little finger

vitality of the finger may be jeopardized by injury to the vessels or by bilateral compression of them in the case of skin graft.

When free full thickness skin grafts are used, the web is divided by an incision which begins one half inch down the palm from the metacarpo phalangeal crease and is carried round to the head of the metacarpal on the dorsum. The edges of the skin are freed and the fingers widely separated. An accurate pattern of the defect is cut from flexible tin foil, and in making it the normal outline of the web should be borne in mind. Especially should it be noted that from the flexor surface of the palm the web inclines dorso proximally to the knuckle and an attempt is made to restore this anatomic conformation since an artificial perpendicular web is unsightly. The graft is taken from a thin and hairless part of the arm or thigh. In cutting the graft, semicircular tongues should be made on it to fit into the incisions

prolonged into the palm and on the dorsum (Fig 42 (b)) To restore the normal dorsal inclination of the web, the two arms of the graft are cut at an obtuse angle (Fig 42 (b))

The graft is accurately trimmed and applied with pressure sponges and dressings after the careful technique imperative in free full thickness skin grafting, especial care being taken to see that the fingers are adequately separated and the correct pressure applied to the web, to ensure free motion at the metacarpo phalangeal joint, and the proper dorsal inclination of the web previously mentioned

DYSTROPHY OF THE FIFTH FINGER

A curious dystrophy of the fifth finger, where there is a lateral curve of the distal phalanx has been described by Kirner and by Kobler The condition is often bilateral is more common in females and occurs round about the age of 10 The finger appears to be short and the tip curves outwards There is no pain or tenderness, and, in fact, beyond the deformity, there are no symptoms No cause is known, though A R Thomas suggests it is the result of an osteochondritis, since in one case the epiphysis was sclero ed and the bone structure was lost The author's case was a young girl of 11 with the condition on both sides There was no evidence of sclerosis or other pathology, and it seems more appropriate to place the condition in the congenital section

CHAPTER III

GENERAL AFFECTIONS OF THE SKELETON

Our knowledge of bone and its pathology has been extensively added to during the last few years, but despite this, it cannot yet be said that the mechanism of abnormalities in bone structure, and of the response of bone to harmful agents is completely or even well understood. Formerly regarded as a connective tissue impregnated with lime to give it durability, it was usually taken that bone acted the part of a scaffolding on which the soft tissues of the body were clothed, served to protect the vital structures it encased, and afforded leverage for the muscular system. Its structure was considered stable to a marked degree, as befitted a tissue invested with such properties. Indeed, with it was associated a conception of a constancy of form and structure above all other tissues. Perhaps the most significant addition to modern knowledge of bone, in sharp contrast to former views, is the realization that bone is a structure of extraordinary instability and sensitivity. Thus it is now appreciated that the osseous tissues are huge reservoirs of the all important element, calcium, and that the calcium content is constantly altering in response to innumerable stimuli.

Of no less interest is the response of bone to fluctuations in its blood supply and to alterations in hormonal activity, the place it occupies in the reticulo endothelial system, and the exact method of its development, growth and maintenance. A proper understanding of these important questions demands some description of the normal development and physiology of bone.

THE DEVELOPMENT OF BONE

The growth of bone begins early in foetal life. In most parts of the skeleton a cartilaginous model of the future bone is laid down and the subsequent process of ossification is known as enchondral ossification. In a few cases there is no preceding stage of chondrification, and this variety of bone development is known as membranous ossification.

Enchondral Ossification.

It has been demonstrated beyond the possibility of error that though a distinction is usually made between the two types of bone develop-

ment, there is, in fact, no essential difference. At those situations in the developing embryo in which enchondral bone is later to be formed, there occurs first a condensation of the *primitive connective tissue*. This is followed by enlargement, and then separation, of the cells by the deposition of an extracellular matrix of chondromucin, until a model in cartilage of the future bone is produced. The mesenchymal cells on the surface of the model at the same time give rise to a peripheral sheath of fibrous tissue—the *perichondrium*—between which and the surface of the model, they persist in their primitive form.

It is interesting at this point to note that the pattern of the model is predetermined. Miss Fell has shown that an isolated rudiment of a chick femur, cultivated *in vitro* develops and maintains its characteristic form. Murray and Selby have also grafted a small basal piece of the posterior limb bud of an early chick embryo on to the chorio-allantoic membrane of an older chick, and found it develop—in the absence of its usual surroundings and in the absence of the strains and stresses to which it is normally subject—into a well shaped femur. It is not in dispute that the ultimate perfection of the adult bone may be attained as a result of environmental stimuli, but the original pattern is inherited and surprisingly perfect.

The first of the changes in the cartilage model preceding ossification is hypertrophy of the cartilage cells at the centre of the model. The cells enlarge, and the matrix of chondromucin becomes modelled into a framework of attenuated trabeculae enclosing them. These trabeculae eventually become the site of a deposition of calcium phosphate from the circulation. Almost simultaneously, the primitive mesenchymal cells near the middle of the shaft between the perichondrium and the cartilage model, become active, show increased powers of division and lay down a matrix of bone, which comes to be like a splint round the mid portion of the shaft. Synchronously blood vessels are developed as irregular spaces lined by endothelium in the sub-perichondrial, or as it is now more properly called, the sub-periosteal layer, for with the appearance of bone the perichondrium ceases to exist.

In the next stage the scaffolding of calcified cartilage in the centre of the shaft is invaded by actively growing cells, also derived from the sub-perichondrial primitive mesenchyme. In the path of this beneficent invasion many of the trabeculae are absorbed, but the stouter longitudinally disposed trabeculae persist and on them, as a scaffolding, bone is elaborated.

The exact mechanism of bone deposition appears to be as follows. The osteogenic cells secrete an *exoplasm* of clear gelatinous fluid—osteomucin. Subsequently in this pre-osseous substance the cells lay down fibrils which ramify in all directions. It is in this pre-osseous matrix and along these fibres that calcium is precipitated, and when this occurs a large number of the osteogenic cells become imprisoned in the new tissue—bone. They shrink and the little spaces they

occupy are known as lacunæ while they themselves are known as bone cells or bone corpuscles. Subsequently they may reacquire their 'osteogenic' capacity should the need arise. Around the vessels the fibrils laid down by the osteogenic cells become concentrically arranged so that vascular channels, surrounded by concentric lamellæ and with numerous bone corpuscles contained in inter lamellar lacunæ come to be the characteristic feature of the histology of bone. Such channels are known as Haversian systems.

After the appearance of the original centre of ossification continued growth in length depends on the continued proliferation of cartilage cells beyond it and on their gradual degeneration and on the calcification and invasion of their matrix by osteogenic cells and blood vessels from the diaphysal ossification centre. Throughout the growth period of post natal life a fine balance is maintained between the two processes so that the proliferating cartilage is not completely replaced by bone until full longitudinal development has been attained. Instead at either end of the bone there is an area of cartilage which by continued proliferation is responsible for the future growth in length of the bone—the epiphyseal cartilage. Greig has suggested that the term cartilage of conjugation would be more appropriate since the mass of cartilage on the side of the disc away from the shaft acquires after birth a secondary centre of ossification and the plate is situated between the two centres but this is a point of little importance.

Cytomorphosis at the Growth Area

Reference must be made in greater detail to the cytomorphosis at the epiphyseal plate. Harris has emphasized that, histologically three zones are to be observed. The first is the zone of *proliferating cartilage*. Traced towards the shaft it will be found that the proliferating cells arrange themselves in longitudinal columns or palsades the number of cells in each palsade being in the region of five. Beyond this is a zone in which the cells of the palsade have become enlarged and degenerate and the chondro mucinous framework has become calcified. This area is known as the zone of *calcified cartilage*. The last zone—nearest the ossified shaft—is that of *active osteogenesis*. In this zone capillary loops from the vessels of the shaft carrying with them small darkly staining cells occupy the spaces between the palsades. The cells spread out over the calcified trabeculæ the cartilage cells finally disappear and bone is deposited. In the meantime the continued deposition of bone from the epiphyseal cartilage is accompanied by the deposit of a shell or ferrule of new bone beneath the periosteum.

The Remodelling Process

The subsequent history of the bone is of equal interest. Once formed there begins almost at once a remodelling process which adapts the bone to suit the stresses and strains to which it is subject. This occurs throughout the bone. Thus in the centre of the shaft the trabeculæ are *gradually removed to form a medullary cavity*,

and thereafter the constant deposition of successive layers of new subperiosteal bone is simultaneously accompanied by the removal of bone on the medullary aspect of the cortex. In the vicinity of the epiphyseal cartilage, where the new trabeculae are constantly being laid down, they are just as constantly being recast into an arrangement suitable to withstand the forces of weight bearing or use. This area of the growing bone is usually known as the metaphysis, and is normally the widest part of the bone. Since the bone grows in length by increments to the metaphysis, the girth of the bone would become too great, and its shape would be other than tubular. The expanded ends of the shaft, therefore, are subjected to a remodelling process which preserves the tubularity of the bone. Jansen believes that this tubulation of the metaphysis is accomplished through the agency of scavenging cells—usually known as osteoclasts. Keith believes that, in addition, the periosteal ferrule exercises a restraining influence, and that by preventing the too exuberant growth of the proliferating cartilage framework, it keeps the amount of remodelling required at a reasonable level.

The remodelling process is not confined to developing bone. Thus in the adult bone special needs are frequently met by readjustment of the osseous struts. In diseases associated with bone deposition there is a constant building up and subsequent reconstruction. In fractures the reparative material is largely removed leaving only that which binds cortex to cortex.

The Factors Controlling Bone Formation.

Certain important considerations emerge from the above account of bone growth and development. In the first place, what causes the cartilage cell matrix to become impregnated with calcium? According to Wiles, even heterogeneous cartilage implanted in the abdominal wall of rabbits becomes the site of a deposit of calcium and phosphate in similar proportion to these minerals in bone, so that cartilage has apparently a specific affinity for them. In addition, it appears that to a great extent the process depends on an enzyme phosphatase, which is synthesized in the cells and leads to the splitting, by hydro-

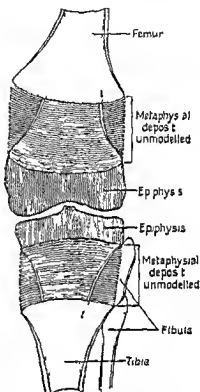


FIG. 43a.—Diagram to show the Normal Remodelling Process at the Metaphysis and the Area of Bone Removed (after Keith)

lysis of the soluble hexophosphoric esters of the blood with the liberation of free phosphoric acid. If there is a sufficiency of calcium salts the excess of phosphate ions thus created will lead to the precipitation of complex and insoluble calcium carbonyl phosphates. Robison's phosphatase is present only in actively ossifying tissues. To some extent also the process probably depends on an adequate amount of vitamin D just as the actual proliferation of the cartilage cells depends on a correct proportion of the growth promoting vitamin A.

The Nature of The Bone forming Cell

The second question of some importance in modern bone pathology concerns the nature of the bone forming cell. In a former terminology the cell of ossifying tissue was known as an osteoblast a title with the merit of simplicity. Lately the osteoblast has been soundly abused and its specific purpose (its high estate) questioned. Actually the dispute is pedantic. Stump and a host of other observers demonstrated that the bone forming cells were derived from a primitive mesenchymal cell which was found between the cartilage model—to which it gives rise—and the perichondrium also a product of it. Stump indeed proved that the cartilage model of the future bone degenerated and was destroyed in advance of the invading mass of osteogenic tissue and he also showed that there was no difference in the mechanism of enchondral and membrane bone formation save that the former was preceded by a temporary cartilage scaffolding. The bone forming cell is therefore a specialized mesenchymal cell and since its presence is necessary to bone formation there seems no reason to discard a term the exact significance of which has been understood for a long time. In adult bone such osteogenic cells are to be found along many of the trabeculae in most of the vascular Haversian—canals of the bone while the bone corpuscles locked up in their lacunae amongst the lamellae retain the privilege of osteogenesis.

The exact method of the remodelling of bone is also in dispute but there is little doubt that bone is removed mainly through the agency of large multinucleated cells generally known as osteoclasts. These are most likely derived as Stump has shown from the fusion of several of the primitive connective tissue cells but according to other workers they arise from the fusion of osteoblasts or from large mononuclear cells of the blood. Ranging themselves around the area of bone to be removed they proceed to excavate it by phagocytosis. The excavated areas are easily seen on histological examination and have been known as Howship's lacunae.

It has been stated that bone may also be removed by halisteresis a physico chemical process consisting of the withdrawal of the calcium salts by the body fluids after the insoluble calcium phosphate carbonate is rendered soluble. It would appear much more likely that halisteresis merely aids the work of the osteoclast for in most cases bone resorption does not consist—as is often loosely stated—of the

conversion of "insoluble crystalline calcium phosphate of bone into soluble or colloidal calcium phosphate," but in the removal of a fibrillated tissue matrix containing these salts. In most of the diseases so often and loosely regarded as examples of *decalcification*, the histology makes it clear that the process, far from being one of the removal of calcium salts, is one associated with the removal of *all* the elements which go to make up osseous structures.

The Rôle of the Periosteum.

The part which the periosteum plays has been a common source of discussion by commentators on bone pathology since the time of Duhamel. McEwan showed that the periosteum acted the part of a limiting membrane to bone, but had *per se* no bone-forming properties, and the accretion of surface bone is due not to the activity of the periosteum but to a layer of primitive connective tissue cells situated between the periosteum and the bone. This has often been regarded as a second or deep layer of the periosteum, but some workers choose to regard it as more intimately connected with the cortex of the bone. All observations subsequent to McEwan's classical work have confirmed his view of periosteal function, and though the phrase periosteal bone is still employed, it is not meant in its literal sense. The term "sub-periosteal bone" is more accurate and equally descriptive.

The periosteum takes a very active part in many of the pathological conditions of bone, and normal bone does not change its shape or form if the periosteum is intact. For this reason, it is sometimes said the phenomenon known as expansion of bone must first be preceded by periosteal separation. This is not borne out by clinical experience, nor is it to be anticipated, since periosteum is a simple enough connective tissue, and if the underlying bone is softened or destroyed, and enlargement occurs, as by giant-celled tumours, the connective tissue of the periosteum is forced to accommodate itself in exactly the same way as other fascial and connective tissues.

GENERAL AFFECTIONS OF THE SKELETON

Our knowledge of bone diseases and their origin is still too incomplete to permit of a classification at the same time comprehensive and scientifically accurate. The following table is suggested only as a convenient one for discussion :

(1) *Developmental Diseases of Bone*

Achondroplasia.

Chondro-osteo-dystrophy.

Dyschondroplasia.

Multiple enchondromata.

Metaphysial aclasis.

Osteogenesis imperfecta.

- (2) *Bone Disturbances due to Errors in the Calcium Phosphorus Metabolism*
- (i) *IN DEVELOPING BONE*
- (a) *Errors in Calcium Absorption*
Deficient Absorption—Lack of Vitamin D—Rickets—Scurvy
 rickets
 Gastro intestinal disease—Coeliac rickets
Excessive Absorption—² increase of Vitamin D—Osteopetrosis
- (b) *Errors in Calcium Utilization*
 Increased phosphate excretion—osteoporosis of acidosis
 Increased parathyroid activity—² osteopetrosis
- (c) *Errors in Calcium Excretion*
 Excessive excretion—Renal rickets
- (ii) *IN ADULT BONE*
- (a) *Errors of Absorption*—Osteomalacia
- (b) *Errors of Utilization*—Osteitis Fibrosa Cystica
 Paget's Disease
- (c) *Excretion* Osteoporosis of toxic gout
- (3) *Endocrine Disturbances*
 Pituitary Errors—Pituitary Dwarfism
 Pituitary Giantism
 Acromegaly
 Thyroid Errors—Hypothyroid Dwarfism (Cretinism)
 (The parathyroid osteodystrophies may properly be regarded as endocrine disturbances but since they affect the bone through the medium of its calcium metabolism they are included in that section)
- (4) *Reticulo endothelial Disturbances*
 Lymphadenoma (Hodgkin's Disease)
 Lipoid granulomatosis
- (5) *Heterotopic Ossification*
 Myositis ossificans progressiva
- (6) *Localized Rarefaction of Bone*
 Post traumatic Osteodystrophy at Joints

DEVELOPMENTAL DISEASES OF BONE

The common developmental diseases of bone apart from the obvious endocrine errors can all be arranged in three groups

- 1 Errors in the proliferation and calcification of the cartilage model (Achondroplasia chondro osteo-dystrophy dyschondroplasia)
- 2 Errors in the remodelling process (Metaphyseal aclasis)
- 3 Errors in osteogenesis (Osteogenesis imperfecta)

ACHONDROPLASIA

(Chondrodystrophia foetalis)

In the disturbance known as achondroplasia the development of the bones laid down in cartilage is at fault. The membranous bones are formed and continue to develop normally. The disease has been known since the earliest times for achondroplasts are dwarfs with easily recognizable features. Their intelligence is often beyond average and their physical strength great. The Egyptian goddess Ptah was an achondroplast and achondroplasts were regularly installed as court jesters in the Middle Ages. Achondroplasia has been characterized by Harris as the most extensive form of perverted bone growth compatible with post natal viability. There are different degrees of the disorder nevertheless and in very severe cases the foetus dies *in utero* and is aborted. A number are stillborn and it is as a result of the study of foetal cases that some information as to the underlying basis of the error has accrued.

CLINICAL FEATURES

At birth a typical achondroplast has a normal sized body very short fat flabby limbs and a large head with a characteristic depression at the root of the nose. The small stature is largely due to the absence of growth of the lower extremities and becomes increasingly evident during childhood. The child walks at the usual age, teeth appear at the normal times and the rolls of fat which disfigure the limbs slowly disappear. Growth is permanently retarded however and the child is recognized as an unmistakable dwarf long before adult life is reached. The smallest cases recorded are Brock's a woman aged 23 who measured 97 centimetres and Bailey's aged 27 measuring 104 centimetres.

Standing erect the tips of the fingers may only reach the great trochanter or the iliac crests whereas in the normal person they extend to the lower part of the thigh. The central point of the body normally at the umbilicus is situated much higher sometimes as high as the xiphoid process. While the proximal segment of the limbs is most affected the achondroplastic hand is also short and broad with the fingers of equal length. With the hand outstretched the fingers diverge in a characteristic fashion to which Marie has applied the term *main en trident*.

The short limbs especially the lower are often curved. This is due to an angular displacement of the two components of the knee the articular surface of the tibia looking slightly outwards.

The trunk is practically normal and the impression conveyed is of the body of an adult to which are fitted four childlike limbs.

The head is both absolutely and relatively enlarged. Its shape is rounded and markedly brachycephalic. The face is broad and at the

root of the short nose is a characteristic depression or indentation. The upper alveolar processes protrude, and prominence of the lower jaw results in prognathism. The sacrum is tilted and in consequence contracture of the pelvic inlet follows, while the outlet is correspondingly increased.

Intellect. Achondroplasts are usually of normal or practically normal intelligence, and frequently they are lively and amusing. In some cases, however, the intellect is impaired and they are backward.

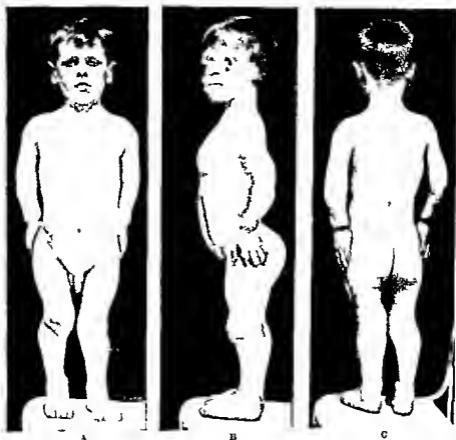


FIG. 44.—Achondroplasia.

A, B, and C. The characteristic appearance of a child suffering from achondroplasia.

for their age. Turner describes the case of a girl of 10 who was unable to wash herself thoroughly, or to attend to the ordinary calls of nature. She took three hours to dress, was debarred from active games, and could only write with difficulty, owing to the characteristic deformity of the fingers and hands.

Their power of mental control is often deficient, and the achondroplast is reputed to be vain, boastful, excitable, fond of drink, and sometimes lascivious. Sexual development is usually normal, but may

be retarded Dwarfs are very muscular and excel in feats of strength they are frequently employed in theatres and circuses partly because of their strength and partly because of their grotesque appearance

PATHOLOGY

The Long Bones of the Limbs These bones are exceedingly short and the most gross restriction is in the shaft In other respects the shaft is normal the muscular prominences are pronounced and the thickness of the shaft is often equal to that of the normal bone The ends of the bones roughly preserve their usual form Hughes Jones has pointed out that in the achondroplastic foetus the epiphysis is practically indistinguishable in size and shape from that of the normal It would seem however that this is not invariably the case and Knaggs believes that the epiphyses are disproportionately large and roughly shaped

The long bones are often abnormally curved or bowed and all changes tend to be most marked in the proximal bones of the limbs though the metacarpals and metatarsals also show characteristic changes

The short bones of the limbs—the os calcis etc—are usually remarkably normal in architecture

The Skull The portion of the skull developed in cartilage—the base—is grossly abnormal Instead of the usual centres of ossification for the pre and post sphenoid and the basi occiput there is an irregular single mass of bone formed by synostosis of the individual centres In consequence of this synostosis the growth of the skull base is retarded—it remains short while the remainder of the skull grows normally The vault comes to be more globular in form and is expanded to make room for the developing brain since little or no contribution to the available intracranial space is made by the base The fontanelles are correspondingly enlarged

The smallness of the base of the skull is responsible for the marked depression at the root of the nose and for the flattening of the face

The Vertebral Column The vertebral column is of normal length but the centres of ossification of the bodies may be smaller than normal The most striking feature is the early synostosis between the body and the arch which in some cases is so severe as to lead to marked diminution in the calibre of the vertebral canal

The membranous bones the ribs and sternum are of normal development

HISTOLOGICAL FEATURES

The most striking feature of the histology of the growth area of the achondroplastic long bone is the great absence of cartilage proliferation so that the normal—and necessary—palisade arrangement is absent Ossification is accordingly greatly hindered by the absence of the normal

scaffolding. It does take place—and the achondroplastic bone grows in length but the process is very slow. The deposition of subperiosteal bone on the other hand proceeds at normal pace so that the diameter of the bone is maintained. The retardation at the growth line may lead to an indurating of the periosteum which is attached to the growth



FIG. 43.—Achondroplasia.

(a) Typical appearance of the bones of the arm. Squat short and broad with broadened metaphyses.
(b) Similar changes in the leg bones.

cartilage and the osteogenic layer of the infolded periosteal shelf may deposit a layer of compact bone over the peripheral part of the metaphysis. This is a secondary phenomenon.

Harris has drawn attention to another feature—a widespread mucoid degeneration of the cartilage cells: the cells become swollen, the capsules distended and the matrix of semifluid consistence. The

mucoid change is patchy and intervening between the mucoid areas may be areas of normal cartilage proliferation and of ossification but the presence of the mucoid areas renders the normal growth in length and the maintenance of the exact form of the bone impossible

The Explanation of the Process

Achondroplasia appears sporadically but there is a distinct hereditary tendency

The exact nature of the process is not known Jansen attributed it to increased amniotic pressure either from hydramnios or undue smallness of the amnion both of which he supposed to lead to ischæmia and consequent disturbance in growth Fairbank has suggested a hereditary defect in the inherent pattern of the bones There is some suggestive evidence that a like condition in animals is associated with an error in development of the pituitary gland and it may well be that an endocrine disturbance is the factor responsible for the deficient proliferation or for the degeneration of the cartilage

The observations of Hughes Jones are of great interest He stresses the fact that the absence of palisade arrangement of the cartilage cells at the growth area is the most striking feature of the disease In other situations e.g. the epiphyses and in bones such as the tarsal bones where no palisade arrangement is normally present growth and ossification proceed as normally He suggests that normally the palisade arrangement of the cells at the epiphyseal cartilage is a response to the presence of osteoblasts and that a catalyst may be necessary to sensitize the cartilage cells to effect this response the most obvious catalyst being a ductless gland product

DIAGNOSIS

With such a very striking clinical picture there should be little difficulty in diagnosis The disease has to be differentiated from rickets and this can be done by an X ray examination of the epiphyses The epiphyseal outline is distinct as there is a considerable deposit of lime in rickets on the other hand the epiphyseal outline is blurred and ossification delayed

Achondroplasia may be confused with cretinism but in the latter there is mental deficiency and stupidity A radiogram of the epiphysis of a cretin shows a transverse line of dense bone in the region of the metaphysis while the consolidation of the epiphysis is delayed until adolescence

PROGNOSIS

The prognosis varies with the degree of the affection but apparently the achondroplast may live to a considerable age

TREATMENT

No known treatment has any effect on the course of the disease

CHONDRO OSTEODYSTROPHY

Chondro osteo dystrophy includes a number of complicated and ill understood deformities, some of which have previously masqueraded under a different name. The earliest cases were reported about the same time by Brailsford and Morquio.

In well marked cases the individual is dwarfed and often lute in walking. The intelligence may or may not be normal.

PATHOLOGY

According to Brailsford this condition which bears a superficial resemblance to achondroplasia is really distinct from it in that the



FIG. 464.—Chondro-osteo dystrophy (Dr Carpenter's case)

child is apparently normal at birth and it is the subsequent development of the skeleton which is at fault.

The growth in length of the shafts of the long bones is interfered with and at each end of the shaft the metaphysis is irregular. The epiphyseal cartilage is increased in thickness and the articular cartilage is also thicker than normal. The epiphyseal centres of ossification usually appear as multiple foci which gradually fuse but in joints subjected to pressure the irregular epiphysis appears to be unable to withstand the strain and distortion compression or fragmentation of the epiphyseal bone takes place.

In the forearm the ulna grows more slowly than the radius and a degree of club hand may develop. At the hip coxa vara may result with an appearance in the epiphysis similar to that of Perthes' disease.

The changes in the vertebral column are very important. The dorso lumbar and cervico dorsal areas are the most commonly affected sites, and in these segments the vertebral bodies may be irregular in shape, size and position the middle third of the anterior surface projecting forwards like a tongue beyond the upper and lower thirds. The upper and lower angles of the body may show gross irregularity of outline. The vertebral bodies may be compressed and deformed by the weight of the superincumbent spine giving rise to clinical deformity, and when the secondary centres appear they do so in an irregular and imperfect manner (Brailsford). Sometimes the development of the articular processes is also defective and when this is so one or more of the vertebral bodies usually at the apex of a kyphus may be squeezed backwards out of line with the remainder of the spine.

Brailsford believes that various degrees of the anomaly may be encountered. Thus the whole skeleton may be involved, or only the spine or the spine and hips or the whole skeleton may be affected but the condition is arrested before deformity arises.

CLINICAL FEATURES

In many cases the attention of the parents is attracted by the occurrence of a spinal kyphosis at the dorso lumbar or cervico-dorsal region. This according to Brailsford, may be so marked and the other evidences so obscure as to lead to a diagnosis of spinal curv. Later other features arise though they may even precede the spinal deformity. Thus the knee, ankle and wrist joints appear swollen as in rickets. The neck may appear to be too short, owing to the cessation of growth at the cervico thoracic junction. By the age of 5 or 6 the child has usually developed into a dwarf of striking appearance, since the trunk is small out of all proportion to the length of the limbs.

In addition to the swelling at certain of the joints deformity may arise, for example ulnar clubhand, coxa vara and genu valgum.



Fig. 46c — Chondro Osteo Dystrophy
(Dr. Carpenter's case)

Fairbank points out that in some cases there is also enlargement of the liver and spleen mental deficiency and corneal opacity

MULTIPLE OR GENERALIZED OSTEOCHONDRITIS

Under this description Dickson Wright has reported a case in which almost every epiphysis in the body became fragmented and distorted as in the common osteochondritis deformans juvenilis There was an associated retardation of growth in the spine

Several other examples of multiple foci of osteochondritis have been reported but in several there have been changes in the metaphysis also and Brailsford and Fairbank believe that the disease is a particular type of chondro osteodystrophy

DYSCHONDROPLASIA

(Ollier's disease)

There has been a tendency in the past to regard the condition which Ollier described in 1899 as dyschondroplasia as identical with the condition variously known as metaphysal aclasis diaphysal aclasis or hereditary deforming chondrodysplasia There are good reasons for separating the two lesions but it is nevertheless certain that cases intermediate between them occur Indeed there are some who regard all the congenital anomalies of cartilage growth at the growing ends of the long bones as variations on a single theme

Dyschondroplasia may be unilateral or bilateral it is perhaps more common as a unilateral affection and occasionally it may be confined to a single bone

PATHOLOGY

The disease is one affecting bone formed in cartilage At the epiphyseal line the cartilage proliferates normally but normal degeneration and calcification and therefore ossification is prevented In consequence as the bone grows in length there persist in the diaphysis masses of unossified cartilage

RADIOLOGICAL APPEARANCES

The typical appearances may be seen in the long bones humerus femur radius etc or in the short long bones of the hands and feet Usually the more rapidly growing ends of the bone are involved

The metaphysis is usually broadened and its texture poor It presents a cystic appearance bridged across by a series of fine septa which tend to run in parallel lines or stripes in the long axis of the bone Occasionally small exostoses project from the surface These are less well formed than in metaphysal aclasis and are usually taken to represent the diaphysal limit of the affected area of the bone

In the short long bones the appearances may be exactly similar or there may be multiple enchondromata

In the humi Hunter and Wiles have pointed out that the disease affects a fan shaped area with the apex at the nutrient artery a characteristic appearance of striping is again produced

The ischium and the pubis may appear fluffy and stippled due to the presence of small rounded areas of cartilage

The epiphyses are unaffected at birth (Hunter and Wiles) but later may also appear speckled

As the child grows the striping of the bones is replaced by irregular mottling and speckling and the affected bones are stunted

DIFFERENTIAL DIAGNOSIS

Hunter and Wiles point out that a positive diagnosis can be made on three main points

- 1 The onset is in early childhood
- 2 The changes are limited to the ends of long bones
- 3 Biopsy reveals that the clear areas in the radiogram are composed of cartilage

Metaphyseal aclasis can be excluded by its striking hereditary tendency by the invariable presence of multiple exostoses which are pedunculated and usually point away from the end of the bones In metaphyseal aclasis the metaphysis is always expanded and the sides of the broadened area are usually parallel there is a sharp line of demarcation between the expanded area and the normal shaft—an appearance well described by Keith as trumpeting In dyschondroplasia the metaphyseal expansion when present is fusiform in outline

Multiple enchondromata The appearance of multiple enchondromata may be present in radiological studies of the hands and feet in dyschondroplasia When multiple enchondromata occur alone therefore there is some justification for regarding it as a localized form of the more extensive disease

In *osteopathia striata* there are lines of increased density in the metaphysis The less dense areas however are not due to masses of cartilage but to bones of normal texture

In *osteopetrosis* there are again rounded or elongated areas of increased density but these are scattered throughout the entire bone and are often arranged in the long axis of the bone

The age of onset the number of bones affected and the characteristic metaphyseal change are sufficient to exclude the generalized fibrocystic diseases

THE CLINICAL FEATURES

The disease usually becomes apparent during the first years of life When unilateral it is seen that one limb is not growing at the same rate as its fellow When bilateral the general growth appears to lag Sometimes the enlargement of the affected hand bones is the earliest feature to attract attention

Later deformity may appear. It is due to weight bearing, or to unequal affection of the metaphysis and a consequent difference in the growth rate between the affected and unaffected parts.

PROGNOSIS

The prognosis as regards life appears to be good. In some cases quoted by Hunter and Wiles, death occurred from the supervention of sarcoma. In others anæmia resulted apparently from the restriction of the available marrow space.

Deformity and secondary arthritis are constant sequelæ.

TREATMENT

The treatment is largely confined to the correction of serious deformities by osteotomy.

Multiple Enchondromata

This term was formerly applied to a disturbance of growth in which multiple cartilaginous tumours were present in the shafts of the short long bones of the hands and feet. Osler pointed out originally that such a condition accompanied the changes in the metaphysis of long bones which he called dyschondroplasia. Nevertheless multiple chondromata were usually regarded as a distinct entity. Hume suggested that they were often present in association with metaphysal aclasis, but that there are obvious differences has of late been stressed by Fairbank, Brailsford, Hunter and Wiles, amongst others. It is now generally believed that in all cases multiple enchondromata are part and parcel of dyschondroplasia.

In the account of dyschondroplasia it was indicated that in contradistinction to the metaphysal changes of the long bones the features met with in the short long bones may be different. In this situation considerable deformity may arise as a result of the presence of masses of cartilage in the bone ends. Thus the bone may be grossly expanded and the expansion may be regular with faint bony striations along the periphery of the expanded area. These striations have been likened by Brailsford to the striations of onion layers. As the chondromatous tissue grows more and more of the bone is destroyed until little may remain of the affected bone save a few scattered bony fragments embedded in irregular striped masses of exuberant chondromatous tissue.

CLINICAL FEATURES AND TREATMENT

The hand and foot disturbance is often associated with gross deformity of a most unsightly nature and the considerable weakening of the bones which results may lead to pathological fractures.

Brailsford points out that judiciously performed operative removal of the excess cartilage in the areas of greatest deformity or maximal weakness will improve the appearance and minimize the risk of fracture.

METAPHYSIAL ACLASIS

(Multiple exostoses diaphysial aclasis hereditary deforming dyschondroplasia)

This is one of the most interesting of the developmental growth disturbances and may well prove important as an intermediate condition between achondroplasia and the other disturbances of euchondral ossification

The disease affects only those bones or portions of bones which are developed both from cartilage and from membrane and it has a well marked hereditary tendency

The most characteristic features of metaphysial aclasis are a failure of remodelling of the metaphysis and the occurrence of multiple outgrowths or exostoses from the surface of the shaft of many of the long bones. In addition there is often some stunting of skeletal growth. Originally known as multiple exostoses the disease was renamed diaphysial aclasis by Sir Arthur Keith but later Greig pointed out that it was really a metaphysial affection and suggested the title here employed—metaphysial aclasis

PATHOLOGY

The membranous bones of the skeleton are immune as are those developed entirely within cartilage such as the tarsal and carpal bones and the epiphyses of the long bones. The condition affects those parts of the skeleton where bone arising in cartilage comes to be surrounded by a sheath of sub periosteal bone—hence it is found at the growing ends of the long and the short long bones. It is most marked where growth is most extensive and most prolonged i.e. the distal end of the femur the proximal ends of the tibia and fibula the distal ends of the radius and ulna and the proximal end of the humerus. It is also well seen at the medial and lateral ends of the clavicle at the cristal border of the ilium the vertebral border of the scapula and occasionally at the neuro-central synchondroses of the vertebrae

The two principal features of the disease are—

- 1 The unmodelled metaphysis
- 2 The exostoses

The Unmodelled Metaphysis This may or may not be the most striking part of the anomaly. The central part of the shaft is usually of normal cylindrical form and of normal calibre. As the bone is traced towards its extremity it will be found that instead of the calibre of the bony tube increasing gradually there is an abrupt increase in diameter and the extremity of the bone—the metaphysis—is in the form of an irregular cylinder with roughly parallel sides. In the growing bone this cylinder is composed of ill trabeculated bone and the surface is covered with a layer of cartilage continuous with the epiphyseal cartilage. In many cases irregular projections—exos-

toses—appear on the surface and occasionally surface projections may be present without increase in the size of the parent bone

The Exostoses These are the most singular feature. Normally most marked at the extremities of the bone they may be found at practically any part of the shaft. Frequently an exostosis marks the junction of the normally calibrated shaft and the expanded extremity. At this situation they are irregularly spiky. Others occur in relation to the unmodelled extremities and these tend to be more globular in shape. As the shaft increases in length those exostoses at first near the epiphyseal cartilage are displaced farther up the shaft. In addi-

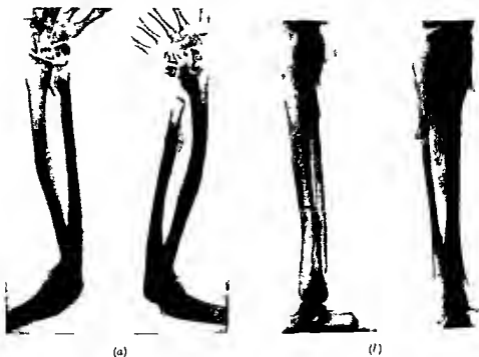


FIG. 4—(a) Metaphyseal Acheis of Forearm Bones (b) Metaphyseal Acheis of Leg Bones

tion they may become obliquely disposed to the shaft with their extremity directed away from the extremity of the bone

The exostoses are composed of poorly trabeculated bone in direct continuity with the bone of the shaft. During the years of growth the exostosis is surmounted by a cap of cartilage also continuous with the epiphyseal cartilage from which progressive growth in size of the exostosis may take place

In association with the above features there is usually well marked interference with growth in length of the affected bones. Keith has offered the suggestion that this is due to the fact that the epiphyseal cartilage becomes spread out over the sides as well as the end of the metaphysis. In the forearm the growth of the ulna is more interfered

with than that of the radius and in consequence it may be the radius becomes curved or dislocation occurs at its proximal extremity. In the leg the fibula lags behind the tibia. In the forearm and the leg an exostosis from one of the bones may cause pressure absorption of the adjacent surface of the neighbouring bone.

The changes in the short long bones are essentially similar and are not to be confused with multiple enchondromata which is part of the disturbance of *dyschondroplasia*.

Two occasional complications of metaphysial aclasis must be mentioned.

(1) The occasional growth of a *chondroma* which projects from the surface of the bone near the epiphyseal cartilage. Such a tumour may attain great proportions and is liable to become chondrosarcomatous.

(2) *Osteogenic sarcoma* may arise in one of the exostoses some times following but occasionally in the absence of operative removal. This leads to rapid increase in size of the exostosis.

The Nature of the Process

Keith originally showed that the essential factor in the disease is a failure of the normal remodelling process which turns the metaphysis down to the calibre of the remainder of the bone. To this normal remodelling and adapting process Jansen applied the term *tubulation*. In addition to the failure of normal tubulation however the exostosis possesses a power of continued growth equal to that of the parent bone. Keith accordingly supposed that the growth of the sheath of sub periosteal bone did not keep pace with the growth of bone from the growth cartilage and the absence of the normal bony ferrule left the cartilage of the growth disc uncovered on the surface and free to give rise to irregular excrescences.

The Time Factor in Metaphysial Aclasis

Though the tendency to the disease is usually inherited and present at birth obvious evidence of its presence appears only after seven or eight years when growth is speeded up and the exostoses become apparent. Exostoses situated towards the mid shaft have commenced to grow at an early age and been gradually displaced to their mid shaft position by subsequent growth in length of the bone.

CLINICAL FEATURES

The process may be local or diffuse. When local one of the extremities is involved while the remainder of the skeleton is normal. In the diffuse type there may be extensive distortion and deformity of the whole skeleton.

The stature is short or even dwarfed. In addition the limbs may show deformities of the nature of bowing or knock knee. Fracture from slight trauma is common but the fragments unite as readily as in normal individuals.

0 GENERAL AFFECTIONS OF THE SKELETON

The most typical feature is the presence of numerous exostoses. These are most common at sites of active growth such as the knee and shoulder. The projections are hard, the skin overlying them is normal and the soft tissues move easily on them.

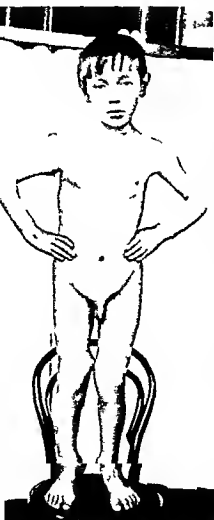


FIG. 48. Metaphysal Aclasis. Multiple Exostoses (Hereditary Deforming Dyschondroplasia)—An example of the disease in a boy 10 years old (Professor Edw'n Brainwell's case).

Note particularly the multiple exostoses around the upper end of the right humerus.

They may be associated with pain if the tumour presses on a peripheral nerve or a nerve root or if the process is inadvertently fractured.

They are also liable to interfere with the free play of associated tendons or may even act as a mechanical obstruction to joint movement in which event they may give rise to considerable disability.

A bursa may form over the projection and become from time to time inflamed while sarcomatous change has also been recorded.

Radiological examination shows an irregularly expanded metaphysal mass with little or no compact cortical bone. The architecture of the interior is altered. The normal cancellous tissue is replaced by a mass of less dense tissue in which islands of normal ossification may be observed.

The exostoses appear as definite projections from the metaphysal region. Their structure is similar to that of the metaphysis—clear interior with a thin shell of cortical bone.

PROGNOSIS AND TREATMENT

The disease has no effect on the general health but there may be grave disability as a result of nerve pressure or interference with joint movement. For all practical purposes the very slight tendency to

OSTEOGENESIS IMPERFECTA

(Fragilitas ossium osteopsathyrosis)

The term *osteogenesis imperfecta* though it could be applied accurately to most of the developmental diseases of bone is usually reserved for the generalized disturbance of bone formation formerly known as *fragilitas ossium*

PATHOLOGY

Knaggs has made a comprehensive contribution to the pathology of this condition. He has shown that in *osteogenesis imperfecta* the epiphyseal cartilage is of normal extent and the zone of calcified cartilage is normal in appearance but that in the zone of ossification—the metaphysis—the trabeculae are slender and delicate and widely separated by interstices filled with cellular connective tissue or fibrous marrow. No cross trabeculae are present as a general rule. The periosteum is thick and there is no compact cortical layer of bone but delicate and discrete sub periosteal trabeculae.

The bones as a general rule are shorter smaller and thinner than corresponding bones of normal individuals at a comparable age, so that the general skeletal development tends to be stunted.

In most cases there have been many healed fractures many in bad position. The consequent deformity producing as it does shortening of the affected bones adds to the dwarfing already present from the feeble osteogenesis.

THE HISTOPATHOLOGY

Knaggs and others have shown that the essential feature of the histopathology of *osteogenesis imperfecta* is a failure of differentiation of osteoblasts. These should normally arrange themselves in rows along the sides of the calcified cartilage trabeculae and then elaborate bone. In this disease the process fails and bone is formed by direct metaplasia of the calcified cartilaginous sheets and from the fibrous tissue of the marrow. The swollen cartilage cells become incorporated in the bone.

In the sub periosteal area where bone is normally formed from osteoblasts which are differentiated *in situ* from the primitive undifferentiated mesenchyme the sequence is again disturbed. Instead of osteoblasts there is produced a type of cell identical with the cartilage cell. In their extra cellular matrix lime salts are deposited as in the epiphyseal growth area, and ultimately transformation of the matrix to bone is effected the cartilage like cells again becoming incorporated in the newly formed osseous substance.

The Nature of the Bone formed

The bones are extremely fragile. This is partly due to the absence of a well formed cortex to the sparse and widely separated trabeculae,

and to the nature of the osseous substance which is less compact than the ordinary laminated bone. The bone is liable to undergo osteoclastic absorption and also in late cases appears to undergo spontaneous disintegration.

ETIOLOGY

There is a well marked hereditary factor in osteogenesis imperfecta. Beyond that nothing positive is known of its cause. Knaggs has made the suggestion that since the outstanding feature of the disease is a



FIG. 49.—Osteogenesis Imperfecta showing Deformities

failure to produce osteoblasts there is an inherent and hereditary inability on the part of the mesoderm to produce this highly specialized cell. In consequence it produces the best cell of which it is capable—the cartilage cell—so that only, or mainly, metaplastic bone is laid down.

There is no evidence of derangement of any of the ductless glands.

An increased serum phosphatase is a frequent finding but it is probably the result of the disease and not a factor in the origin or production of the lesion.

CLINICAL FEATURES

It is possible to recognize several types of clinical case. In all of these

the pathology is similar and the difference which is largely one of degree is the result of the different grades of severity of the disease.

In the fatal form the disease is severe and the child is stillborn or survives only a very short time. There are multiple fractures some healed at birth while the cranium shows grossly imperfect ossification and consists merely of a membranous bag with a few plaques of poor bone embedded in it. It is probably the damage imposed on the imperfectly-protected brain during labour that results in stillbirth.

In the infantile form, a less severe form of the disease is present. At birth there may be some stunting and evidence of fractures but the ossification of the skull is more advanced. The child survives

for a year or two but the bones are fragile and break at a touch. The skull may assume a globular shape and may appear large in proportion to the rest of the body. True hydrocephalus may develop and this again may be related to intracranial damage at birth.

3. In the adolescent type often called osteogenesis imperfecta tarda the child may appear normal at birth and during childhood the only disturbance observed may be a special liability to fractures from comparatively minor injuries. The ossification of the skull may be almost perfect but one or two soft areas may be found on examination. As time passes the tendency to fracture on slight provocation is lost.

The disease may on rare occasions be encountered first in adult life when a case which was slight at birth and during adolescence becomes active or when a case which has regressed spontaneously is reactivated.

In all types there is a well marked hereditary and familial tendency and prominent features are

1. The stunting of growth
 2. The occurrence of fractures from trivial violence. The fractures are often sub periosteal and unite readily often more so than in normal bone and the callus is often more dense than in normal bone. The fractures are distinctive in that they cause little or no pain or tenderness—largely because they are sub periosteal. It is largely for this reason that so many are allowed to heal with deformity. Sometimes the fractures are associated with mild febrile attacks.

3. The occurrence of blue sclerotics. This has been observed in the infantile and late types of fragility and is due to increased visibility of the pigmented choroid through an abnormally translucent sclera. Apparently there is no alteration in the thickness of the sclerotic or in its histological structure so that its translucency is said to be due to some alteration in the quality of the fibrous tissue composing it. In this connection it is interesting to note that when blue sclerotics are present without fragility of the bones there is a peculiar liability to sprains and joint disturbances.

RADIOLOGICAL APPEARANCES

These depend on the age of the patient and the severity of the condition. The bones in severe types may show practically complete absence of cancellous texture the cortex appearing as a faintly pencilled line. The bones are shorter than normal and occasionally broader. In less severe types the long bones are stunted diffusely rarified and may have expanded club shaped extremities. Fractures or old deformity following fractures are often apparent. In adult cases the shafts of the bones appear to shrink and show a dense relatively thick cortex with no medulla. In sharp contrast to the slender and often deformed shaft the ends of the bones are expanded and show coarse cancellation with poor density. Ultimately the long bones may

denser bone

The ribs are usually bent sharply downwards at their angles and the thorax is therefore greatly deformed. This may be accentuated by the occurrence of scoliosis. The pelvis shows asymmetrical and irregular deformity. The skull shows irregular ossification with islands of denser bone in a poorly calcified matrix—the so called Wormian bones.

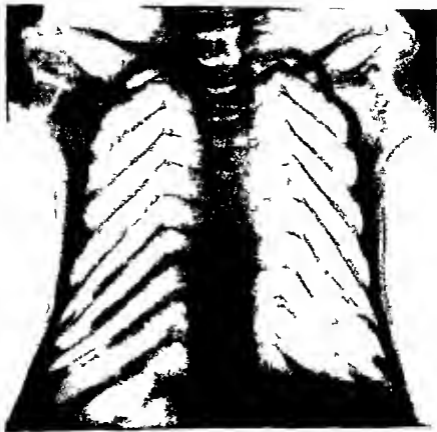


FIG. 50—Osteogenesis Imperfecta

The radiogram of the chest wall of a child suffering from osteogenesis imperfecta. Note the delicate outlines of the ribs and the existence of fracture at the angle of practically every rib.

DIAGNOSIS

The diagnosis is usually evident but occasionally rickets may afford some difficulty especially since fractures are common. In rickets however the radiological picture is characteristic—the epiphyseal cartilage is broad and fuzzy the edge of the metaphysis to the zone of calcified cartilage is irregular and poorly defined and the metaphysis itself is cup shaped and expanded. On the other hand the rarefaction of the rest of the bone is considerably less than in osteogenesis imperfecta.

PROGNOSIS

In the majority of cases death is the outcome. Occasionally adult life is reached but the constant occurrence of fractures, the repeated confinement to bed and the forced inactivity make it burdensome. In only a very few cases is the condition apparently arrested and the liability to fracture lost.

TREATMENT

No specific treatment is known. Measures dietetic and otherwise to promote the general well being are indicated. Care should be exercised in handling children with the disease but when fractures occur they are treated along the usual lines and if healing takes place with deformity osteotomy may be carried out.

BONE IN RELATION TO CALCIUM METABOLISM

An adequate supply of calcium, phosphorus, magnesium and other elements is necessary for the normal metabolism of bone. These elements are brought to the bones by the blood serum which may be viewed as a saturated solution of calcium and phosphorus in a balanced ratio of ten units of the former to four of the latter.

Mineral calcium is mainly responsible for maintaining the physico-chemical equilibrium necessary for the normal irritability of muscle and nerve and its exact role is to lessen irritability at the neuromuscular junctions in the myocardium and in striped and unstriped muscle. Despite its essential function there is no conservation of it in the body and the spongiosa of the skeleton forms its only reservoir. Phosphorus is essential for the regulation of the acid base reaction of the body fluids and is likewise stored in the spongiosa of the skeleton. Normally the blood serum is a solution in biological saturation with the calcium phosphate of the bones.

Part of the calcium and phosphorus in the serum is in ionic form and is formed by the dissociation of the calcium phosphate of the bones under the influence of parathormone, the active secretion of the parathyroid glands. The dissociated calcium and phosphate ions remain in equilibrium with the solid calcium phosphate and are subject to the Law of Ionic Dissociation. Consequently an increase in the phosphate ions in the serum from any cause leads to a fall in the serum calcium with deposition of calcium phosphate in the bones. A fall in phosphate ions leads to a rise in calcium ions and in serum calcium with solution of calcium phosphate from the bones and the excretion of the excess of calcium.

Thus there are two factors controlling the calcium balance between blood serum and spongy bone: (1) the phosphate content of the serum (the amount found normally in the blood serum is from 1.5 to 4 units per 100 c.c. in adults and from 5 to 12 units in children); (2) the parathormone content of the serum. Increase in the amount of

parathormone leads to increased solution of calcium and phosphate from the bones. The excess of calcium is largely got rid of by excretion, but there may be a rise for a time at least in the serum calcium. It is generally accepted that an increase in parathormone acts mainly by hastening the excretion of blood phosphate in the urine, though in high doses it apparently acts to some extent also by dissolving the calcium phosphate of the bones.

The relationship of phosphatase to calcium metabolism has been well explained by Taylor. Mention was made in an earlier section of the necessity for the presence of this enzyme if bone was to be deposited. Normally phosphatase is present at only three sites: (1) at the site of phosphorus absorption (mucosa of bowel), (2) where phosphorus is stored (bones), (3) where phosphorus is excreted (kidney and bladder).

Its action is not specifically to form bone, but to convert organic into inorganic phosphorus. In bones it is found only at sites of active ossification viz the epiphyseal line and beneath the periosteum, and it is the local concentration of it that determines ossification. In certain types of bone absorption there is a large amount of phosphatase in the plasma. This according to Taylor is due to the fact that in bone absorption osteoblasts are stimulated to form phosphatase and new bone (as a compensatory mechanism), but the phosphatase is constantly swept away into the circulation and there progressively destroyed.

While the whole question of the utilization of calcium and of the calcium phosphorus bone ratio is the most complex and interesting part of calcium metabolism there are two other factors to be considered viz calcium absorption and calcium excretion. Calcium must be present in the diet in sufficient quantity before absorption of the required minimum ($\frac{1}{2}$ –1 gm daily) is possible. A sufficiency of calcium is of paramount importance during the growing period, and in its absence bone of a soft, partially calcified type (osteoid tissue) is laid down.

Mellanby has particularly stressed the dietetic aspects of the problem, and has shown that two types of diet are bad:

1. A diet containing substances which promote growth without at the same time supplying a sufficiency of calcium.

2. Foods which encourage growth, but which interfere with the retention of calcium salts in the body and so prevent its deposition. The actual absorption of calcium is governed by the Vitamin D content of the body which may be obtained from the diet, or synthesized in the body by the action of sunlight (or ultra violet radiation) on the sterol of the skin. Nevertheless, the absorption of calcium is difficult, because so much of the calcium in the diet is insoluble, and what is soluble is so liable to be precipitated if adverse conditions obtain. Thus alkaline carbonates may throw its soluble salts out of solution, while an excess of split fat in the bowel (as in coeliac disease) leads to the combination of free fatty acid with the calcium to form soaps.

Acidity of the intestinal contents favours its absorption, as does systemic acidosis deliberately produced by ammonium chloride

Calcium which is absorbed from the alimentary tract but remains unused is at once excreted by the urine and faeces. Similarly an excess of calcium in the blood—by depletion of the spongiosa—leads to excessive secretion by the kidneys. It is apparent, therefore, that efficient calcium metabolism depends on a variety of factors, and when any of those factors are upset, the skeletal system is apt to show coincidental changes. The majority of these skeletal disturbances were originally considered as bone diseases. Thus they undoubtedly are, but the modern tendency is to approach their consideration through the underlying metabolic derangement. The following classification is therefore suggested

Bone Diseases resulting from Errors in Calcium Phosphorus Metabolism

I IN DEVELOPING BONE—

A Errors in Calcium Absorption

Deficient Absorption

(a) Lack of Vitamin D—Rickets

(b) Gastro intestinal disease—Coeliac Rickets

Excessive Absorption

(a) ? Increase of Vitamin D—Osteopetrosis

B Errors in Calcium Utilization

(a) Increased phosphate excretion—osteoporosis of acidosis

(b) Increased parathyroid activity—? osteopetrosis

C Errors in Calcium Excretion

(a) Excessive excretion—Renal rickets

II IN ADULT BONE

A Errors of Absorption—Osteomalacia

B Errors of Utilization—Osteitis Fibrosa Cystica

Paget's Disease

C Excretion

Osteoporosis of toxic goitre

RICKETS

Rickets is a disease of the lower classes, and is especially common in industrial districts where poor housing, mal nutrition, smoky atmosphere and lack of sunlight are common. These factors favour a lack of vitamins, and it is now generally assumed that rickets is a deficiency disease due to lack of Vitamin D. Improved conditions have reduced its incidence in this country, but in the industrial towns of the English Midland and Northern Counties the disease is still prevalent, and a Rickets Clinic established recently in Sheffield had as many as 500 children attending for treatment. Mellanby believes that, while the grosser manifestations are less frequent, a considerable proportion of children of the hospital classes show sufficient bone changes to indicate that they have passed through a period of defective bone calcification short of florid rickets.

The commonest type of the disease begins during the early years of infancy and is extremely rare after the age of four. It is known as *infantile rickets*. Comparable disturbances may arise at other age periods, however—*late rickets* and *osteomalacia*.

PATHOLOGY

The main interest of the orthopaedic surgeon is in the bony manifestations of the disease, but the metabolic disturbance affects most of the body tissues

The Skeletal Changes The bones of the skeleton are soft and porotic, and bend easily from the weight of the body or from other external causes. Normally the epiphyseal line of the long bones is a well defined narrow strip of cartilage 2 mm deep, but in rickets it forms a wide irregular band and the metaphysis is broad and irregular from excessive proliferation of the cells of the epiphyseal line. The bone deposited is patchy in distribution and uniformly poor in calcium salts.

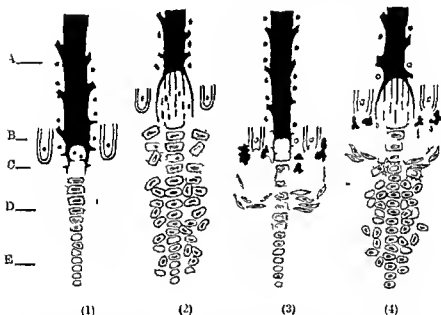


FIG 51—Diagram to Show the Characters of the Growth Area in Various Conditions.

In (1) a normal bone is the regular column of proliferated cartilage and of calcified cartilage cells.

In (2) rickets, note the irregular and excessive proliferation of cartilage cells, the poor line deposit in the zone of calcified cartilage, and the scanty bone formation in the ossification zone. The whole growth area shows a greatly increased thickness.

In (3) simple scurvy there are intrametaphyseal hemorrhages and a broad, irregular zone of ossification. New bone as it is formed is broken up by the hemorrhage.

In (4) scurvy rickets, in addition to the changes in rickets (as in (2) above) there are the evidences of scorbutic capillary hemorrhage.

A—Diaphysis B—Capillary with accompanying osteoblastic reaction C—Zone of ossification D—Zone of calcified cartilage L—Zone of proliferating cartilage (After H. A. Harris)

The histology of the process is instructive. The cartilage in the proliferating zone is hyperplastic, but instead of the normal parallel arrangement of the cells, the proliferated cells are arranged more haphazardly. The extent of the zone is increased.

In the zone of calcified cartilage the deposit of lime salts in the intercellular matrix is greatly deficient, or even absent.

In the zone of ossification the bone deposited by the osteogenic

cells from the diaphysis is poor in quality deficient in lime and of patchy distribution. Associated with this is a poor development of the bone marrow. Fig 51 (2)

In the metaphysis osteoclastic activity is almost in abeyance so that the extremity of the bone appears misshapen and unmodelled.

These changes are most marked at the most actively growing part of the bones and only affect the bone being deposited during the active phase of the disease. Bone formed before that is for the most part normal while bone formed after the active phase of the disease is passed is also normal.

The Deformities of Rickets During the active phase of the disease enlargement of the metaphysal segments of the long bones gives rise to obvious swellings at the bone ends. These are especially prominent at the costo-chondral junctions and at the lower end of the radius and tibia.

When the child is able to crawl or to walk the long bones of the lower limb may become bent. The femur becomes bowed anteriorly and to the lateral side. The neck shaft angle of the femur may be diminished (coxa vara) the tibia bowed or the knee may assume a valgus attitude.

The pelvic deformities are of most importance to the obstetrician. The whole pelvis may be flattened or it may assume a trefoil shape as in osteomalacia (q.v.).

The skull is broadened the forehead square and bosses of new bone may form in the parietal and frontal regions.

The vertebral column may come to assume exaggerated curvatures.

The Production of Rickets Rickets is not due to any inherent defect in the skeletal system. This fact has been clearly established by experimental and therapeutic researches which have also demonstrated that the essential factor is a disturbance of the calcium phosphorus metabolism on which the growth and maintenance of bone is so absolutely dependent.

Experimentally rickets can be produced by withholding fresh foods and by feeding with a diet containing in all balanced amount of calcium and phosphorus. It has been quite definitely shown that disturbance of the mineral content of the diet has no part in the production of human rickets but a constant feature of the latter disease is a low



Fig. 51.—Rickets. Leg bones showing Deformity in a Case of Healed Rickets. The coxa vara bowing of tibia and resulting tilt, are shown.



FIG 54—Multiple Osseous Deformities
Boy 5½ years old

- 8 Delayed dentition, with irregular, soft, decaying teeth
- 9 Pale skin flabby subcutaneous tissue typical wizened look
- 10 Poorly developed muscles, with delay in walking
- 11 Enlargement of the liver and spleen

- 2 Restlessness during sleep
- 3 Disinclination to be moved or to use the limbs
- 4 Evidences of catarrh of the mucous membranes, e g recurrent diarrhoea, constipation, and bronchitis

5 Evidences of irritability of the central nervous system—convulsions, laryngismus or other types of spasmodic

In a typical case of rickets, the clinical picture is very characteristic, and the prominent features may be tabulated as follows

- 1 Large head open fontanelles and craniotables
- 2 Prominent abdomen
- 3 Separation of the recti muscles over the protuberant abdomen
- 4 Narrow chest
- 5 Enlarged epiphyses
- 6 Beaded ribs—the rickety rosary
- 7 Bowing of the long bones



FIG 55—Severe Rickets Deformities
Child, aged 4



FIG 56—Genu Valgum

This is the natural standing position of the patient, and shows the external rotation of the tibia as well as the knock knees.

There may also be evidence of a thickened periosteum while fractures of the long bones are frequently seen.

2 In the *second stage* the epiphysis appears as a mottled irregular ill-defined shadow. The metaphyses are ragged but are now broader than normal running out from the side where the pressure is greatest. Periosteal thickening has disappeared but if bowing has occurred the cortical part of the affected bone will be thickened on the side of the concavity of the curve.

3 In the *third stage* the shadow becomes denser and at the end of the metaphysis a dense line appears. This is due to the deposition

12 Intestinal derangement—constipation or diarrhoea

RADIOLOGICAL FEATURES

The X-ray changes are characteristic and important. In this connection Lovett describes four stages.

1 *The Acute Stage* The normal rounded appearance of the epiphysis is replaced by a cloudy area containing one or more indistinct centres of ossification. The metaphysis is flayed out and deficient in line shadow.



FIG 57—Rickets in the Acute Stage

The acidity of the disease is evidenced by the fluffy expanded epiphyses.

of lime and while it is often considered characteristic of scurvy it also occurs quite frequently in rickets. The epiphyseal shadow is more clearly outlined, but is still inclined to be mottled rather than clean cut. This is essentially the stage of repair. The most characteristic feature is the marked difference in size between the end of the shaft and the epiphysis.



FIG. 78.—Rachitic Deformity of the Tibia and Fibula after the Condition has Healed

4. In the *fourth stage* the characteristic increase in breadth of the metaphysis is still present, but the bone is now clearly defined and shows a normal content of lime salts. This stage marks the end of the process, the bone being now completely repaired.

DIAGNOSIS

There should be no difficulty in diagnosis when the complete picture has developed, but the disease may occasionally be confused with congenital syphilis and infantile scurvy. The congenitally syphilitic

child has usually other signs of syphilis, but occasionally the chief lesion may be a syphilitic osteochondritis. The epiphyseal region is tender, œdematous, hot, painful, and swollen, there is loosening and separation of the epiphysis, which can usually be moved on the shaft, with the production of muffled crepitus. The epiphysis may even be lying free in a cavity filled with pus. There is usually a history of parental syphilis and the child responds to anti-luetic treatment.

In infantile scurvy swelling also occurs, it is not limited to the region of the epiphysis but encroaches on the shaft. There are usually hæmorrhages in other situations, and the general signs of scurvy are present.

TREATMENT

The treatment may be considered under three headings—the medical treatment, the prevention of deformity and the treatment of existing deformity.

1 Medical Treatment, Prophylactic and Curative. A full discussion of this aspect of rickets is out of place here, but some points may usefully be considered. Mellanby has stressed the fact that while a milk diet—cow's or human—is by far the best for infants, yet in many cases the milk does not contain a sufficiency of vitamin D and should therefore be supplemented by substances rich in the vitamin—cod liver oil and halibut liver oil being satisfactory.

A largely cereal diet is particularly bad, for cereals in some obscure way interfere with the action of vitamin D and may render an otherwise sufficient amount of the vitamin inactive.

Rickets may be cured by administration of one of the vitamin D containing foods or by one of the standard preparations of the vitamin (e.g. calciferol). The effect of these is enhanced by the addition of a calcium preparation (calcium carbonate or calcium phosphate). Ultra violet light therapy is an invaluable adjunct.

2 The Prevention of Deformity. When the bones are so soft that they are easily bent by pressure, or muscle strain, the child's movements should be so controlled that little or no pressure is exerted upon the limbs. He should not be allowed to sit, stand, or walk, but *should lie on his back most of the time and only be allowed to roll about in bed.* In difficult children it is often advisable to fit rickets splints. These are narrow strips of wood, which extend from the crest of the ilium to beyond the sole of the foot. They are firmly fastened to the body and limbs by bandages and prevent the child from sitting up or getting on to his legs. To take the place of exercise which is precluded by the position or by the splints, massage should be instituted.

3 The Treatment of the Established Deformity. Findlay has pointed out that in cases of very bad deformity in young children a rickets producing diet may be given so that when the bones become soft the limbs may be straightened by wrenching and splinting. When the alignment has been improved, a bone hardening, anti-rachitic diet

may then be recommenced. He has successfully treated a case in this way.

Deformity is more usually corrected, however, in one of four ways by splints, by gradual manipulation, by the osteoclast, or by osteotomy.

(a) *Correction by Splinting* This method is used where the deformity is slight and the disease still active. It is employed particularly in young children, especially in those below the age of four, and is most useful in deformities of the lower limb. The splint is a narrow wooden one. It extends from the thigh to beyond the sole of the feet in cases with knock knee, while in cases of bow leg it reaches from the crutch to beyond the foot.

The method is slow and requires continual supervision to ensure a good result and to prevent the formation of sores. In the case of genu valgum, the splint is fixed securely round the pelvis, and round the lower part of the leg and foot. A steady pull is then secured, by means of a rubber bandage over the point of maximum deformity, i.e. round about the knee joint. The splint is worn continuously, night and day.

(b) *Correction by Gradual Manipulation* This method is useful in very young children during the active stage of the disease. It consists of gradual correction by manual pressure, under anaesthesia. It is not applicable when the deformity is near a joint, as the manipulation may only stretch the ligaments of the joint and leave the deformity untouched. Fraser states that it is indicated in deformities which are unsuitable for treatment by splints, and where osteoclasis or osteotomy is for any reason contra-indicated.

(c) *Correction by Osteoclasis* By this method the bone is fractured at the point of maximum deformity, either manually over a wooden wedge, or by the use of a special instrument—the osteoclast. When the former method is used, the child is placed on a low table and the wedge inserted beneath the area of maximum deformity, and at right angles to the long axis of the limb. The affected bone is then grasped by the two hands, one above and the other below the deformity. The weight of the surgeon's body is then brought to bear on the bone, which first bends, and, as more force is applied, eventually breaks. A complete fracture having been produced, the position is corrected and a plaster of Paris case applied. This is retained until the fracture has completely united, usually in about six weeks after the manipulation.

A Thomas's osteoclast is particularly useful for securing a similar result in older children. The limb is carefully protected by pads, and the osteoclast closed fairly quickly, so that the bone breaks rather than bends. The after treatment is similar to that of the fracture produced by the previous method.

(d) *Correction by Osteotomy* This method is used when the deformity is in the neighbourhood of a joint, where the osteoclast cannot be used.

Osteotomies should never be carried out until the radiogram indicates that at least the third stage of rickets, according to Lovett's classification, has been reached. There is then eburnation, clearness, and regularity of outline. If corrective operations are attempted before this period non union is apt to follow.

The osteotomy may be of the linear or the cuneiform type and only three fourths of the bone should be divided by the osteotome, the remaining part being fractured manually. If complete correction has been obtained, a plaster of Paris cast is applied for six weeks.

GENU VARUM

This term or the more common one of bow leg, is applied to a lateral curvature of the leg which involves either the tibia, or the tibia and the femur. Where the leg is curved anteriorly the condition is termed anterior bow leg. It never occurs in healthy children, its existence being presumptive evidence of some degree of rickets.

The deformity is of course due to the effect of body weight the soft bones gradually yielding, usually without fracture, though green stick fractures have occasionally occurred at the point of maximum curvature. The bowing is usually restricted to the tibia, and most commonly to its lower two thirds. There is usually an inward rotation of the lower end of the bone on the long axis of the femur, since it is a flexible three cornered rod and cannot on that account be bent laterally without rotating. The toes, therefore are turned in, and, when the child stands with the feet together, the knees are widely separated.

On walking an obvious waddle is present, resembling that seen in bilateral congenital dislocation of the hip.

It is important to distinguish between rachitic anterior bow leg and the sabre-blade tibia of syphilis. The syphilitic tibia has always some periosteal thickening along the anterior border, whereas in anterior bow leg the thickening is endosteal and more pronounced on the concave side of the curve.

TREATMENT

In the earlier cases walking in distorted attitude should be avoided, and the mother taught to manipulate the leg several times a day, care being taken that no strain is placed on the epiphysis while the manipulation is being carried out.

When the deformity cannot be improved by this method a Knight's brace may be used. This consists of two steel uprights attached to the shoe with a soft leather pad attached to the upper end of the medial upright to prevent undue pressure on the medial condyle of the femur. The lateral upright extends to the head of the fibula, and the two are joined by a calf band. The bowed leg is drawn towards the medial bar by a broad leather cuff laced about the leg.

inside the lateral bar the medial bar may be gradually bent until over correction is secured. This usually takes from six to twelve months in young children.

When the deformity is most marked towards the middle of the shaft osteoclasis is a quicker method of correction while the anterior form of bow leg should be treated by osteotomy.

In severe degrees of anterior bow leg the deformity may resist correction at one sitting and several osteoclases or osteotomies may

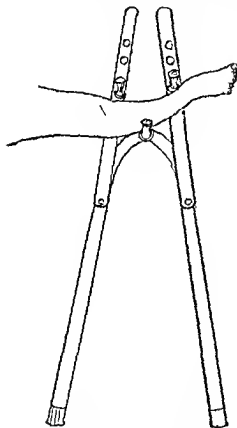


FIG 59—Buckle Osteoclast
Method of use shown in case of bowed tibia

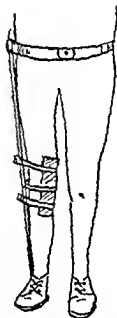


FIG 60—Walking splint used in the
Correction of Treatment of Knock knee

have to be done at different levels on the tibia at intervals of three or four months. The osteotomy may have to be accompanied by a simple transverse tenotomy of the tendo calcaneus to permit it to lengthen to a corresponding degree.

Slow osteoclasis is dangerous and not over eight seconds should be taken to fracture a bone by the osteoclast. Apart from the great mechanical benefit of the operation there is an enormous mental one for the patient who has hitherto looked dejected and ashamed of himself now assumes a self confident pose.

GENU VALGUM

The deformity of knock knee develops, as a rule, in early childhood, and is almost invariably due to rickets. There is an inward projection of the knees, and the leg deviates from the long axis of the femur at an abnormal outward angle. The deformity arises because the line of weight transmission through the femur passes to the outer side of the centre of the knee joint, the lateral condyles of the femur and tibia have thus to bear more weight than the medial bone, softened by rickets, is readily compressed, and conversely, the absence of any great weight bearing strain on the medial aspect of the knee allows the bone in that situation to develop more rapidly than on the outer side. As the deformity is developing, the tibia rotates outwards on the femur, as a result of traction by the lateral ham strings. Marked eversion and outward rotation of the tibia are, therefore, often present.

The average child of 3 or 4 is able to stand with the medial condyles of the femur and the medial malleoli approximately touching. Any marked separation of the malleoli when the knees are in apposition indicates the presence of knock knee. When knock knee is present, the child walks in an unsightly manner, since the knees rub together, and the line of gravity is transposed to the outer side of the knee joint. The gait is lurching, with an exaggerated side sway of the body at each step to preserve balance. Falls are common. Synovitis of the knee arises from joint strain. The deformity disappears when the knee is flexed, since the posterior surfaces of the condyles with which the tibia articulates in full flexion are not affected.

TREATMENT

In mild cases in which the disease is still active, considerable improvement, if not cure, can be obtained by manipulation. With one hand holding the leg just above the ankle, and the other placed over the lateral condyle of the femur, short adduction movements are made to rectify the position temporarily, to stretch the shortened structures on the lateral aspect of the joint, and to exert mild intermittent pressure on the medial condyle. During the night, a long lateral splint is fitted and the knee is pulled towards it by a simple bandage.

In cases which resist this treatment, a Jones's walking knock knee brace, as shown in Fig. 60 may be used.

In cases of any severity, it is much better to perform an osteotomy of the femur, the bone being divided in the supracondylar region from either the lateral or the medial side. The author uses the medial approach, a small incision being made down the bone in front of the adductor tubercle. The osteotome is inserted at right angles to the long axis of the shaft which is then partially osteotomized. The complete fracture is produced by manipulation. After correction, a

plaster-of Paris spica extending from the pelvis to the foot is worn for about six weeks. The child is then allowed up on a walking caliper and carefully supervised for some months until the fracture has fully united and any tendency to recurrence of the deformity has disappeared.

SCURVY AND SCURVY RICKETS

The anti scorbutic vitamin C is found in the majority of fresh food stuffs—fruit juices, green vegetables and to a lesser extent in potatoes, milk and raw meat. Since it is destroyed by heating at 100°C it is absent in dried, canned and preserved foods and in vegetables subjected to prolonged boiling.

The absence of vitamin C from the diet gives rise to the clinical condition of scurvy, the characteristic symptom of which is hæmorrhage in various parts of the body. The orthopaedic surgeon is concerned with its manifestations in bone.

The disease most commonly occurs in infants of from six to eight months who have been fed exclusively on artificial food which has had its vitamin content destroyed in the process of manufacture or which has never possessed a vitamin C content at all. It also occurs in adults who are deprived for a time of fresh food—as in old people living alone and subsisting on an inadequate diet of bread and tea.

A diet deficient in vitamin C need not of necessity be deficient in the other vitamins. Nevertheless it is frequently so and if there is in particular a deficiency in vitamin D a rachitic element may be added to the scorbutic in the case of the growing child, while in the adult there may be some evidence of osteomalacia.

Thus it is well to distinguish two varieties of scorbutic disturbance in the young:

(1) *Scurvy*

(2) *Infantile Scurvy rickets* (Barlow's disease)

PATHOLOGY OF SCURVY

The cardinal feature of scurvy is hæmorrhage—from the gums, the alimentary tract, the subcutaneous tissues and in bone. The hæmorrhage is capillary in origin and occurs at sites at which new capillaries are sprouting—in bone for example at the most actively growing metaphyses and beneath the periosteum. It is thought that vitamin C controls the nutrition of capillary endothelium or the amount of intercellular cement which binds the endothelial cells together.

The pathological change in the affected bone has been well described by Harris.

From the capillary loops growing up into the zone of ossification from the diaphysis there occurs an irregular and patchy oozing of blood so that small pools of blood collect and disrupt the newly forming bone, the calcified cartilaginous struts and even the proliferating cartilaginous

palisades (Fig 51 (3)) The blood clots and contracts, and is replaced by fibrous tissue or, in favourable circumstances by bone

In very extreme cases the hæmorrhage may be sufficient to disrupt the growing area, so that massive death may occur with separation of the epiphyses

The sub periosteal hæmorrhages are often extensive the periosteum being stripped from the shaft for a considerable distance They organize or are replaced by bone exactly as in the intrametaphysial hæmorrhages

In *true scurvy rickets*, there is in addition to the features outlined above some irregular proliferation of the cartilage columns otherwise the effects are similar (Fig 51 (4)) In both there is an important secondary effect for the metaphysial disturbance is also responsible for failure of differentiation of the bone marrow and this with the repeated hæmorrhages may lead to a degree of anaemia

CLINICAL FEATURES

The child may or may not appear ill nourished The earliest features are restlessness and fretfulness and it is apparent that one or more of the extremities is not being used Handling of the parts produces pain, and ultimately the child screams when ever he is turned over or moved

Systemic reaction, in the shape of fever is absent in the initial stages

When the limbs are examined the observer may find obvious swelling fluid in character in

relation to the shaft of one or more of the long bones Such swellings are said to be ten times more common in the lower limb bones than in the upper and are due to sub periosteal hæmorrhages

The joints may appear swollen and are exquisitely sensitive to touch—so much so that an infective condition may be simulated On

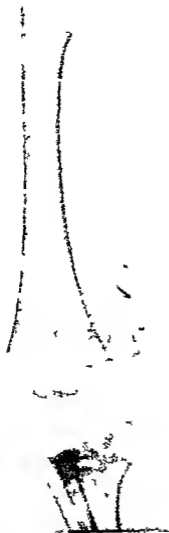


FIG 51—Scurvy showing Sub periosteal Hæmorrhage of the Femur

the other hand the immobility of the parts may simulate paralysis and this feature is often known as the "pseudo paralysis of scurvy."

Hæmorrhages may also occur into and beneath the skin, and the gums may be swollen and spongy.

DIFFERENTIAL DIAGNOSIS

In the absence of visible or palpable hæmorrhage, there may be difficulty in the diagnosis of scurvy. The conditions most liable to confusion in the early stages are anterior poliomyelitis, injury to joint bone and nerve, osteomyelitis, arthritis, and syphilitic osteo chondritis.

According to Harris the syphilitic lesion in contrast to scurvy, affects the more slowly growing end of a bone as for example the elbow. It is also common in the short long bones of hand and foot, the proximal end of the femur, and the distal end of the tibia.

The absence of fever serves to rule out the inflammatory conditions, and the history, the dietetic conditions, and the radiogram serve to distinguish the others. The response to treatment in scurvy is also dramatic, in sharp distinction to the other conditions enumerated.

The typical X ray appearance is seen in Fig 61. Fairbank describes, as a sign of diagnostic value, a clear line in the bone parallel to the growth disc and separated from it by a clear area.

TREATMENT

The administration of vitamin C in any of its forms leads to rapid cure. Within twenty four hours pain and crying cease, and in a few days hæmorrhages are beginning to heal. It is some months however, before the bone texture returns to normal.

The easiest way to exhibit vitamin C is as fresh orange, or lemon juice or by the synthetic vitamin product—ascorbic acid.

Rest in bed is indicated in the early stages and later, massage and exercises may be usefully employed to augment muscle tone. Unprotected weight bearing should be forbidden until there is radiographical evidence of a return of structure to the metaphysis, as otherwise deformities may arise.

CELIAC RICKETS

The frequent occurrence of skeletal changes in association with celiac disease has long escaped recognition. Parsons, who has contributed an enlightening study of the disorder, has pointed out that this may be due to the fact that celiac disease is usually recognized in early childhood, while the bone changes do not appear till the age of seven, when they are often attributed to late rickets.

PATHOLOGY

The bone changes appear only in late and long established cases and are similar to those of rickets. The metaphysis is broad and irregular the palisade arrangement of cartilage cells is lost and in

place there is an irregular hypertrophy of the cells. The zone of calcified cartilage is narrow and its calcium content is poor or absent, while the osteogenic process is retarded or arrested and instead of bone there is deposited an imperfect type of osteoid tissue.

CLINICAL FEATURES

In association with the characteristic appearance of coeliac disease—pallor, cachexia, muscular hypotonicity and abdominal swelling—there is lack of body development—stunting. In addition there may be skeletal deformity. Genu valgum in particular is a common feature. Enlargement of the distal ends of the radius and ulna are also

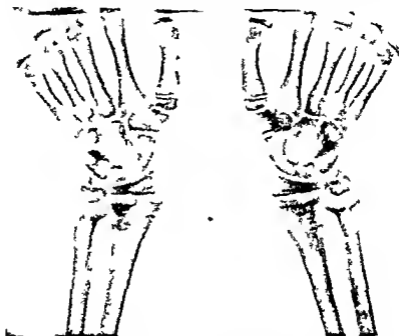


FIG. 6.—Coeliac Rickets (Professor Fraser's case)

frequent signs but occasionally still more extensive deformation may be present—enlarged costo chondral junctions, Harrison's sulcus, kyphosis, coxa vara, bow leg, etc. Fractures may occur with mild trauma.

There may be recurring attacks of tetany.

RADIOLOGICAL APPEARANCES

The X-ray appearances are very variable but the whole bone is usually fragile and porotic. Parsons believes that the other changes are similar to those of rickets, i.e. the metaphysis is swollen and its extremity uneven. The epiphyseal cartilage is broad and fuzzy. In most cases transverse striations of denser bone may be detected in the neighbourhood of the metaphysis. Harris believes that these

striations are indicative of periodic arrests of growth but most people regard them as indicating bands of more perfect bone deposited during periods of temporary improvement in the disease

THE BLOOD CHEMISTRY IN CELIAC DISEASE

In coeliac rickets there is invariably a lowered serum calcium content and often a comparatively low phosphorus value as well. The occurrence of tetany is the result of the low serum calcium

ETIOLOGY OF CELIAC RICKETS

In coeliac disease there is inadequate utilization of the fat of the diet. Since the natural fats are valuable sources of the vitamin D there is probably some resulting deficiency of the vitamin. In addition the excess of free fatty acid leads to precipitation of the calcium and the phosphorus of the diet as in soluble carbonate and soaps. There is therefore deficient absorption of these minerals from the alimentary tract. The mechanism of the bone changes is thus similar to that of rickets—the blood circulating in the bone has a low serum calcium and phosphorus value and in consequence bone which is actively growing is laid down in a poorly calcified form and in irregular manner. The late onset of the bony changes is due to the effect of growth. Parsons suggests that in consequence of the fat deprivation there is virtually starvation and therefore arrest of growth. The absorption of calcium and phosphorus though greatly diminished appears to be sufficient to calcify the fragile bones of coeliac disease so long as there is little or no growth but directly any considerable growth appears this defective absorption results in the development of what is for all practical purposes rickets.

TREATMENT

Since the mechanism of the disease is so exactly comparable to rickets Parsons advocates the use of (1) ultra violet therapy (2) irradiated ergosterol (3) a fat free diet.

Deformities which demand it are treated along similar lines as the post rickets deformities.

OSTIOPETROSIS

(Albers Schonberg's disease marble bones osteo-sclerosis fragilis generalisata congenital osteosclerosis)

Albers Schonberg in 1904 was the first to describe a rare bone disease associated with increased density of the skeleton. Less than 40 examples of the condition have been described and the disease has been known by many titles some of which are indicated above. The condition has not infrequently affected several members of a family and there have been minor differences in the pathology of the disease in individual families though it tends to be true to type in the members of any particular group.

PATHOLOGY

In this disease both the membrane and cartilage bones are involved. The characteristic change is the increased density and thickness and complete loss of trabeculation of the affected bone. Any or all of the bones may be affected and the condition is usually symmetrical. In the case of the long bones the usual differentiation into cortex and medulla is lost and the change may affect any part of the bone but is most common at the metaphysis. In the growing long bone there is no alteration in the size or appearance of the epiphyseal cartilage but the bony nucleus of the epiphysis may show similar changes. In addition to the loss of architecture the bone density is grossly increased and the texture appears closely granular. The increased thickness of the bone indicates that the condition affects not only the bone developed from the epiphyseal cartilage but that growing from the sub periosteal osteogenic layer.

The most marked changes are found in the most rapidly growing extremities of the long bones—the lower end of the femur and radius and the upper end of the tibia and the humerus.

Brailsford points out that if hard rays are employed in radiographing the bones it becomes apparent that there are lines of increased density alternating with faint lines of decreased density though the effect of the whole is to indicate a greatly increased general density.

The ribs are similarly affected—thick dense and apparently structureless. The vertebrae may be uniformly dense or a dense zone at the upper and lower thirds of the body may be separated by a zone of normal density in the middle indicating that the process is affecting the bone laid down from the cartilage end plates of the body. The skull may be so dense that no detail of its architecture can be made out as in a case of Norman Dott's reported by White. The bones of the carpus and tarsus are ringed by a layer or layers of dense bone the result of peripheral accretions.

The extent of the change depends on the age at which the disturbance begins. If it does not commence till after birth the first indication is a dense streak at the extreme limit of the metaphysis but if it has commenced *in utero* even at birth a considerable part of the diaphysis may show the change. The disease progresses during the growth period by the addition of further dense accretions both sub periosteal and from the epiphyseal cartilage so that in the adult the bones still show the characteristic changes.

Relation of Increased Density to Bone Strength. It is well known that so called marble bones are liable to fractures especially in the adolescent. It was for this reason that it was originally grouped with fragilitas ossium. It is generally accepted that the increased bone density in osteopetrosis is not an index of increased strength. Thus it is said to be possible to cut a so called marble bone with a knife the sensation experienced being similar to that on cutting

chalk so that Pirie has suggested the name chalky bones for the condition. Brailsford is probably correct when he suggests that conflicting statements on this point are due to the fact that the brittleness of the bones depends on the age of the patient and the stage of the disease since the liability to fracture steadily decreases after adolescence.

Secondary Pathological Changes Two sets of symptoms secondary to the bone changes are of importance as it is usually for these that the patient seeks advice. They are due to the involvement of the hæmopoietic and nervous systems by encroachment of the thickened bone.

The progressive sclerosis of the long bones gradually reduces the medullary cavity and the bone marrow to a degree incompatible with normal blood formation. At first over activity of the residual marrow results in an increase of reticulocytes and nucleated red cells in the peripheral blood but later a true aplastic anaemia develops. In attempted compensation there is enlargement of the liver, spleen and lymphatic glands of the body.

In the skull the thickening is apt to restrict the size of the foramina leading to pressure on and paralysis of the cranial nerves. Thus blindness, nystagmus and ocular palsies may arise. Occasionally the density of the bones of the skull may lead to hydrocephalus and when the clinoid processes are grossly increased there may be injurious pressure on the pituitary with signs of hypopituitarism.

In considering the diagnosis it is to be noted that a condition closely resembling marble bones is found in those working in cryolite, a compound of fluorine, sodium and aluminium while Spedder (1936) found the same condition in the phosphatic zones of Morocco in the local inhabitants as well as in animals. The condition is said to be due to the ingestion of fluoride of calcium.

ETIOLOGY

The etiology of osteopetrosis is obscure. There is no doubt how ever since it affects membrane bone and cartilage bone and may commence *in utero*—as soon as the earliest centres of ossification are laid down—or after birth that it is a defect of the ossification processes.

Various theories have been proposed. Thus Robertson found in his case a high vitamin D content of the diet but this is not general.

The theory which finds most acceptance at present is Dupont's—that the primary factor is parathyroid overactivity—which is founded on the discovery of a parathyroid adenoma in the case of his own. There is some experimental evidence to support this as it seems that while daily injections of parathormone in animals leads to mobilization of skeletal calcium the reverse is obtained if the injections are prolonged for the osteoblasts are stimulated to deposit bone.

Ellis suggests that while it is difficult to credit the theory of a continued hyperparathyroidism it may be that periods of parathyroid

activity alternate with periods of normality, and in support of this he quotes Brailsford's observations on the lines of alternating density which appear on special radiography.

ATYPICAL FORMS OF OSTEOPETROSIS

Melorheostosis (Leri).

The condition was first reported by Leri in 1922, and since then more than thirty cases have been reported. It is a rare condition in which certain bones, or portions of a bone, are petrosed but different in certain ways from ordinary "marble bones". The distinguishing features are (1) the changes are confined to one limb, (2) the outline of an affected bone is definitely distorted, (3) the presence of pain, often severe, and (4) limitation of movement in the joints formed by the affected bone. The affection is usually limited to one limb, and occasionally to one bone of a limb.

PATHOLOGY

A portion of the cortex of one of the limb bones is irregularly enlarged, sufficiently to give rise to a swelling with an undulating surface. Between one undulation and another, a linear band of increased density may extend, which has been likened to a "flow" of hyperostosis. The condition is sometimes known as "*Monomelic Flowing Hyperostosis*". Leri employed his original title because the hyperostotic areas in appearance resemble "candle drippings".

Sometimes the lesion is associated with deformity of the affected bone. Thus in the lower limb, bowing of the femur and of the tibia is common.

Kraft has lately distinguished three types of the disease —

1. Where a whole extremity is affected—so that the dense cortical proliferation appears as a regular and continuous flow from shoulder to fingers, or hip to foot. Usually it is limited to one side of the bone, and in some cases appears to occupy the distribution of a nerve or vessel without having any apparent relationship to them.

2. In the second group, only half the extremity, the proximal half, is involved.

3. In the third group a whole extremity is irregularly involved, and there are multiple interruptions of the flow.

ETIOLOGY

Nothing is known of the etiology of the condition, but it has been suggested by Moore and De Lormer that the deformity associated with it is the result of overloading a bone less well adapted to withstand strain, or to the mechanical leverage effect exercised by the

hyperostotic processes Fairbank suggests that fibrosis of the marrow may be the fundamental change present

CLINICAL FEATURES

Apart from the deformities, or the swellings resulting from the local lesion, there may be "rheumaticy pains" in the affected extremities It is usually accepted that the pain is a sequel to chronic arthritis of the joints of the limb, with which the condition is usually associated There is usually limitation of movement at the affected joints Occasionally, there is an indefinite complaint of progressive muscular weakness

Osteopetrosis with Superimposed Disturbances.

Brailsford has brought forward evidence to show that metabolic and other diseases of childhood may be superimposed on the original changes of osteopetrosis This is an important observation, and no doubt accounts for some of the complicated skeletal diseases of childhood, as well as rendering their clinical diagnosis difficult

Rickets and renal rickets may modify the picture by leading to imperfect calcification of areas of developing bone alongside the hyperostotic areas of osteopetrosis This has been borne out pathologically by the demonstration of osteoid tissue in the metaphysis of bones where the diaphysis showed the usual changes

The condition is also occasionally associated with diffuse deposits of calcium in the kidney, lungs, vessel walls and ligaments, and in this form again the metaphysial area is thickened and poorly calcified Brailsford suggests that it is allied to osteogenesis imperfecta, the deposits of calcium being due to a grave metabolic disturbance, possibly set up by secondary sclerotic changes in the kidneys

Osteopathia Striata (Voorhoeve)

In this condition, zones or striæ of dense bone are found in the long axis of a long bone or in the ilium The condition gives rise to a characteristic X ray appearance, which is, perhaps, its main significance, for it does not give rise to clinical evidence, nor does it induce secondary pathological changes

Its cause is unknown

OSTEOPOIKILOSIS

This condition was described by Albers Schouberg in 1915 It is characterized by the presence of dense spots in large numbers in the long and short bones. The skull, vertebrae and ribs seem to be exempt The spots, which may be very numerous, are round, oval or lanceolate with their long axes parallel to the long axis of the bone They are usually uniformly dense, but may have clear centres, and are grouped towards the end of the bone in the epiphyses They give rise to no symptoms, and are usually discovered by chance Schmorl found that they consisted of numerous closely packed trabeculae in the lamellae lying mostly in a longitudinal direction

RENAL RICKETS

The association of chronic renal disease with changes in the skeletal tissues was first reported by Lucas in 1883. Since then many complete and instructive studies have been made amongst others by Parsons and by Barber. The latter in particular has made especially detailed observations on the bone changes and has emphasized the fact that the disturbance of growth may be so great as to lead to dwarfism. He has applied the term Renal Dwarfism to this extensive type of the disease.

CLINICAL FEATURES

In a number of cases symptoms are present from birth. In others the child is normal for a few years before symptoms arise.

These may be considered in two groups.

1 Those pertaining to the renal lesion.

2 Those pertaining to the disturbance of growth.

(1) *Features pertaining to the Renal Lesion.* The most prominent kidney signs are polydipsia and polyuria. Indeed thirst is often the earliest evidence of the disorder. The urine is of low specific gravity and the urinary output may be as much as 1200 to 3700 cc daily. Albumen and casts are usually present at some stage of the disease and the cardiovascular symptoms of renal origin may appear though rarely. Ultimately signs of kidney failure—headache, drowsiness and gastrointestinal disturbance—arise and ultimately death occurs from uræmia. From the time of onset of the disease tests of urinary function show a marked lowering of renal efficiency. The blood urea is constantly raised. Thus in eight cases reported by Barber the blood urea varied from 73 to 300 mgm per cent while Ogilvie records a case where the blood urea shortly before death was 490 mgm per cent.

(2) *Features pertaining to Disturbance of Growth.* The children are always stunted in growth, often to a degree not equalled by any other form of infantilism. The body weight is correspondingly small though malnutrition is not present. The mental development is normal up to the age of puberty. The secondary sex characteristics do not develop however and after the age of puberty mental sluggishness is the rule.

The Bone Changes. Genu valgum is the commonest manifestation of renal rickets but there may also be enlargement of the epiphyses at the wrist and ankles, a costo chondral rosary, Harrison's sulci or bow leg. Occasionally bending occurs at the enlarged epiphyses.

The age of onset of the bony changes is variable. Genu valgum becomes apparent only between eleven and fourteen years but Parsons has found bone changes as early as sixteen months. The average age of recognition of deformity is between five and seven.

THE RADIOLOGICAL APPEARANCES

Parsons has given the most comprehensive account of the X ray changes in renal rickets and it is his descriptions that are followed here. He finds that the bone changes fall into three well defined groups.

(1) *Atrophic Type* The whole bone is fragile and porotic and the epiphyseal cartilage broad and irregular. The metaphysis is broadened and its extremity uneven and ragged. These changes of course are similar to those seen in rickets.

(2) *The Florid Type* In this type as in ordinary rickets the end of the metaphysis becomes cup shaped from the greater absence of



FIG. 63.—Renal Rickets at the lower ends of Tibia and Radius.

Note the cupping of the distal end but no gross changes in the shaft. The epiphyses at the lower end of both femora at the pericaps of both humeri were separated.

calcium in the central axis of the bone than beneath the periosteum. The broadening of the metaphysis is also more marked.

(3) *The Woolly, Stippled or Honeycombed Type* In this type the metaphysis is grossly increased and appears irregularly honeycombed or stippled or woolly, the bone appearing moth eaten as if it were being eaten away subperiosteally.

The changes do not progress to a uniform degree in all the bones of the skeleton but in the majority of cases the type of change—atrophy, florid or woolly—is constant for all the bones affected.

THE PATHOLOGICAL CHANGES

The renal lesion is typical of chronic interstitial nephritis. On occasion (as in Brockman's case) there has been in addition a condition of congenital cystic disease.

The Skeletal Changes Parsons has had an opportunity of observing the bone changes in a typical case. The epiphyseal cartilage showed increased thickness the calcified zone was the site of an irregular deposit. The metaphysis was broadened and contained islands of cartilage amongst ill formed osteoid tissue. In consequence of the presence of so much cartilage the metaphysis is apt to be bent on the shaft leading to considerable deformity which may simulate displacement of the epiphysis.

Brockman has described the histological differences at the growth disc in ordinary and in renal rickets. Instead of excessive proliferation of cartilage cells and abundant formation of osteoid tissue with little if any fibrosis in the adjacent marrow as in rickets we find in renal rickets a partial or complete failure of the normal proliferation of cartilage cells and an absence of proper cartilage columns. The formation of bone is limited and that which is formed is being actively absorbed by osteoclasts. There is much fibrous tissue extending into the adjacent marrow while the rest of the red marrow is completely fatty. The vascularity of the justa epiphyseal region is increased though islets of cartilage may be found deep in the metaphysis.

THE BLOOD CHEMISTRY IN RENAL RICKETS

The blood serum shows an extreme degree of hypæmia and a high grade of nitrogen retention. It has usually been found that the blood phosphorus value is high while the serum calcium is low or normal. It is low when tetany is present. Chown has lately pointed out that in some cases and in all cases at some period the reverse obtains and there is hypercalcaemia and increased excretion of calcium by the kidney.

THE CAUSE OF RENAL RICKETS

The nature of the essential disturbance in so called renal rickets is not positively known. In the usual view there is in consequence of a pathological renal state an endogenous disturbance of calcium and phosphorus metabolism. The kidneys are unable to excrete phosphate so that it tends to accumulate in the blood serum. Part of it is thrown out into the gut where it combines with the calcium of the diet and so prevents the absorption of the latter. In this way a low calcium form of what for all practical purposes is rickets develops. The serum calcium may be maintained at a comparatively normal level by the withdrawal of calcium from the spongy skeleton. This is the view to which Shipley and Parsons subscribe.

Chown has recently brought forward another possible explanation. In a case of his own he discovered aplasia of the pituitary. The infant died at an early age but characteristic bone changes were already present along with well marked thirst and polyuria. The kidney changes on the other hand were apparently slight and consisted of compression and destruction of the renal tubules by cal

OSTEOMALACIA

carteous deposits There was hypercalcaemia Chown regards the pituitary changes as significant Pituitary disease in childhood is itself often associated with dwarfing of the stature and infantilism while polyuria and thirst are the features of diabetes insipidus which is due to a lesion of the associated diencephalon He supposes that the bone changes are also attributable to the pituitary disturbance which in some way at present obscure is known to govern the growth of the skeleton Excess of calcium—derived either in excess from the diet or from the maintenance of absorption and cessation of the growth of the skeleton—leads to increased renal secretion of the mineral It is the lowered renal excretion of calcium which in his opinion leads to the calcium deposits in the renal substance and secondary destructive and sclerotic changes in the kidneys In this view renal rickets is a misnomer and the condition would be more appropriately called pituitary rickets These views are of great interest but cannot be held as proved and the first explanation is at the moment the more generally acceptable

PROGNOSIS

Complete cure of the skeletal dystrophy may occur if the individual survives for after the age of sixteen or seventeen there is much less liability to tetany and the demand for calcium to ossify the bones is in abeyance

During the course of the disease there may be remissions associated with improvement in kidney function and better excretion of phosphate

Nevertheless the ultimate prognosis as to life depends on the renal pathology The renal dwarf is especially liable to intercurrent infection which is especially apt to prove fatal The occurrence of bone deformities is itself a grave omen and the average duration of life after their appearance is said to be less than two years It is important for the surgeon to remember this as operative interference in addition to being of little avail is almost certain to hasten a fatal issue

TREATMENT

The bone lesions do not respond to treatment by vitamin D high calcium diet or ultra violet light therapy as do cases of ordinary rickets Indeed by ensuring the increased absorption of phosphorus vitamin D and ultra violet radiation actually do harm No beneficial treatment is known In the active stage of the osteodystrophy however weight bearing should be prevented and splints may be applied to limit deformity until spontaneous remission of the disease occurs

OSTEOMALACIA

Deficient absorption of calcium and phosphorus in infancy leads to rickets If similar conditions prevail in adolescence late rickets may ensue Even in the adult when all bone growth has ceased bone is not in a static condition but is constantly being absorbed and re

formed. When the absorption of calcium and phosphorus is restricted in the adult a general rarefaction of the skeleton results which is known as osteomalacia.

THE NATURE OF THE BONE CHANGES

All the bones of the skeleton show marked rarefaction and are so soft as to be cut readily by the knife. Frequently the bones are grossly deformed. The trabeculae of the bones are attenuated or absent and the interstices of the spongy bone filled with vascular fibro fatty connective tissue.

THE HISTOLOGICAL APPEARANCE

The trabeculae of the bones are thin and eroded and in places replaced by fibrous tissue or osteoid tissue. Osteoclastic activity is marked and the Howship's lacunae large. The interstitial tissue is vascular and consists of young connective tissue.

THE DEFORMITIES

Any of the bones of the skeleton may become grossly deformed but bones subjected to muscular strains or the influence of posture or gravity are the most grossly disturbed. The lower limb bones are therefore more affected than the arm bones and curvatures of the femur and tibia and coxa vara are common. Kyphosis is also frequent. The changes in the pelvis are amongst the most interesting. The pressure of the femoral heads is associated with medial displacement of the acetabula. The angle of the pubic symphysis therefore becomes more acute and the pubis projects as a sharp beak. The sacral promontory rotates forwards under the body weight and the upper pelvic aperture therefore assumes a trefoil shape. This particular form of pelvis has been used as an argument against the resemblance between rickets and osteomalacia since in rickets it is more usual to find a flat pelvis. Preston Maxwell has disposed of the objection with certainty however for he has demonstrated that when the rachitic infant is carried about in a sitting posture a typical tri radiate or trefoil pelvis develops whereas if the infant is not walking and is kept on its back the typical flat pelvis results. The rib deformities are similar to those of rickets. Fractures are common.

The blood chemistry examination usually shows little deviation from normal values for calcium and phosphorus although the phosphorus values tend to be high. Normal serum phosphatase is also found.

THE CAUSE OF OSTEOMALACIA

Formerly regarded as an endocrine or toxic disturbance modern opinion is unanimous that osteomalacia is an adult form of rickets in which as a result of lack of calcium the himestores of the skeleton are depleted in an attempt to preserve the circulation of this essential element.

The deficiency of lime may be due to defective absorption from

1 Inadequate amounts in the dietary

2 Lack of vitamin D

3 Gastro intestinal disease which prevents the absorption of the lime

It may be contributed to by excessive excretion of calcium and it is not unlikely that more than one factor is operative in individual cases. The following clinical types may be recognized —

1 *Osteomalacia of Pregnancy* In the late months of preg-



FIG. 64.—Osteomalacia

A radiograph from a severe case of osteomalacia. The effect of a light beam on the bones is well seen.

nancy a large surplus of calcium is necessary for ossification of the fetal skeleton, and during lactation there is added excretion of calcium in the milk. In this type however the essential factors are a lack of sufficient calcium in the diet to supply the additional requirements or insufficient amount of vitamin D to permit of the absorption of a sufficient quantity. In other words there is either a relative or an absolute lack of calcium. It is sometimes urged that the term osteomalacia be reserved for this osteoporosis of pregnant women, but the bone changes and the basic cause of the other forms are so precisely similar that this serves no useful purpose.

2 *Starvation Osteomalacia* This form of bone softening is

occasionally observed in circumstances of great food deprivation and is due partly to an absolute lack of calcium in the diet and partly to avitaminosis. It was seen in an extreme form in Russia during the starvation period following the revolution, and in Vienna. It is occasionally met with in the depressed industrial centres of the North of England.

3 The Osteomalacia of Idioopathic Steatorrhœa In this disease there are fatty stools, dilatation of the colon, and anaemia. The history usually goes back to infancy, and the lack of skeletal development is due to inability to absorb calcium as a result of the excess of free fatty acid in the bowel. In more severe and long standing cases the changes of coeliac rickets appear. At any time in the course of the disease, if the supply of calcium for absorption is insufficient for general requirements the deficiency may be made good by withdrawing calcium from the bones so that bone absorption occurs and in some cases the features of osteomalacia.

CLINICAL FEATURES

All varieties of osteomalacia are rare in this country, but the puerperal form is common in China. The most prominent symptom is backache across the loins or in the dorsal region and sometimes about the hip. Often there is acute aggravation of the pain due to spontaneous collapse or fracture of the bones. A reduction in height from spinal collapse is frequent while the back may show clinically an arched kyphosis in the dorsal region, collapse of the whole back with flat lumbar region, and characteristic deep furrows in the soft parts. There is also great muscular weakness which may simulate paresis, especially where atrophy is present as well. The muscular hypotonicity may lead to an uncertain, feeble gait. Ultimately the individual may become bedridden. Occasionally signs of tetany may arise.

RADIOGRAPHY

The X ray picture is final. There is a calcium deficiency of the bones especially the vertebræ, which may be wedge shaped but more characteristically fish tailed with marked concavity and enlarged discs. The vertebræ are compressed, especially in the lumbar region in some cases irregularly so.

THE COURSE OF THE DISEASE

The duration of the disease if untreated varies from five to twenty or more years depending on the exact factors producing it. In the pregnancy type there is often remission when pregnancy and lactation have terminated.

TREATMENT

The administration of a diet of high calcium value, combined with a sufficiency of vitamin D and exposure to sunlight or artificial heliotherapy are curative.

OSTEITIS DEFORMANS

Osteitis deformans was described in some detail by Sir James Paget in 1876, and is often known as *Paget's disease*. It is certain, however, that examples of the disease were known previous to this, and the name of the disease had already been proposed by Czerny in 1873.

The disease has a fairly universal distribution in the human race, and has also been identified beyond doubt in horses and monkeys.

CLINICAL ASPECTS

The disease usually begins between the ages of thirty six and fifty and Roberts and Cohen point out that in those first seen at later ages there is usually a history of some years' standing. The sex incidence is practically equal. It is often unilateral to begin with and the onset of the disease is insidious and its progress slow. Pain in the lower limbs, thigh or hips is often the initial feature, it may be aggravated by exercise, or be more pronounced at night. Muscular cramp, or tenderness on palpation of the muscular bellies may be complained of.

Sometimes the onset of deformity first attracts the patient's notice—gradual bowing of the legs or the development of a spinal curvature are common in this respect. Gradual increase in the circumference of the head may be a notable feature, the patient's attention may be directed to it by the frequent necessity for larger sizes in headwear.

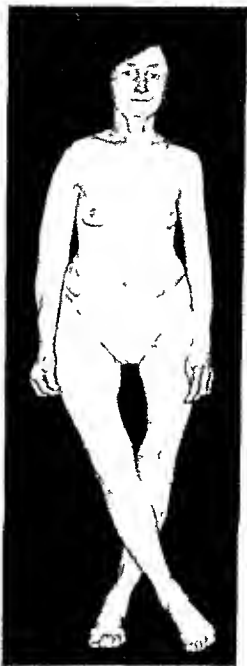


Fig. 63.—Paget's Disease of the Skeleton

Later, the gait becomes ungainly, partly as a result of deformity, partly because of the muscular weakness. Arthritis ultimately supervenes, particularly in the weight-bearing joints, and still further disturbs the gait.

Other symptoms are the result of the primary effects. Thus head ache and vertigo may result from the cranial thickening. Compression of the cranial nerves in the foramina appears if and when the lumen of the foramen is encroached upon. Spinal cord compressions have also been reported in a number of instances.

Spontaneous fractures from trivial violence are wont to occur, especially in the femur and the tibia.

There is one other risk to which sufferers from Paget's disease are liable—the development of osteogenic sarcoma in one of the affected bones.

VARIETIES OF OSTEITIS DEFORMANS

(1) *Monostotic Form* In this form only one bone is affected.

(2) *Unilateral Form* Often beginning unilaterally, it apparently in some cases may persist as a one sided affection. It is said that if its distribution is limited to one side there is a rise of temperature $+0.5^{\circ}\text{C}$ on the affected side.

(3) *Facial Type* In certain of the recorded cases enlargement of the jaws has been a feature. Either the upper or lower jaw, or both, in whole or in part may be involved.

RADIOLOGICAL FEATURES

Roberts and Cohen found that the bones most commonly involved, in order of frequency, were—skull, tibia, femur, pelvis, then less frequently radius, hand, foot, humerus, and ulna.

Changes in Skull The earliest change is a blurring of its surface outline together with some flattening (from softening). Later progressive thickening takes place in the outer table, but the new bone is not regular and appears as irregular islands of dense bone, giving the calvarium a mottled or coarsely piebald appearance. Ultimately the distinction between outer and inner table is lost, and the latter also acquires a ragged worm-eaten appearance. The base of the skull may show comparable changes.

Changes in the Spine The changes in the spine are less frequent than in the skull. They consist of a woolly appearance of the bodies, with coarse striæ at the periphery and horizontal striæ near the upper and lower surfaces. The bodies may be flatter and squatter than normal and abnormal curvatures may be present.

The Pelvis The pelvis tends to assume a trefoil shape, as a result of the pressure of the femoral heads. The bone appears thick and massive but the texture of the bone is altered, it now appears mottled and blurred, while occasionally coarse striæ are apparent throughout the cortex.

The Long Bones The affected bones show increased thickness due to enlargement of the cortex. The bones are variously deformed usually the natural curves of the bone are accentuated but sometimes the deformities are more bizarre and the femur may show in S shaped deformity. The texture of the bone in the early stages is porous—the bone appears stippled from irregular absorption. Later there is a granular appearance throughout the thicker cortex from the deposition



Fig. 66—Lagets Disease of the Femur with the long illustration of Neck

of calcium salts while still later the amorphous granular change in the cortex is replaced by coarse longitudinally running trabeculae which gradually become distinct and defined. As regards the individual bone this stage may be taken to mark the end of the process.

In addition to deformation by bending the bone is liable to pathological fracture during the stage of granular amorphous calcification.

Occasionally ovoid translucent areas are covered by a thin layer of lime occur. These are cysts and resemble in many respects the cysts of

parathyroid osteodystrophy Calcification of arteries is also a common feature

THE PATHOLOGY OF OSTEITIS DEFORMANS

The Bone Changes The bone changes are characterized by thickening softening and deformity and later by recalcification and hardening

The Skull Changes Knaggs describes three stages in the pathology of the skull changes. In the first or *vascular stage* there is a deposit of finely porous bone beneath the pericranium and this is red in colour due to the permeation of a very vascular connective tissue. In the second stage—of *advancing sclerosis*—the thickness of the skull is still more increased and the calvarial sutures obliterated. The bone on the inner table is very condensed but still finely porous. On the outer table there is also a narrow layer of dense but fairly porous bone. In the area between the tables the bone is again red and spongy in texture and its interstices are packed with vascular connective tissue. In the stage of *diffuse complete sclerosis* the condensed type of bone is present for the most part throughout the whole thickness of the calvaria.

The skull base shares in the change but to a less extent in consequence of its smaller amount of soft spongy bone. Despite the remarkable increase in thickness the available intracranial space is not encroached upon to any great extent the new bone being deposited on the external aspect. In the base however the neural foramina may be reduced in size.

In the Spine the changes are in all respects similar. There is thickening rarefaction and softening of the various parts and in consequence of the weight bearing function some of the bodies may collapse. Secondary changes—synostosis of adjacent bodies even ankylosis of a segment of the spine—are common. The combined result of the osteitis deformans and its associated deformities is to lead to marked reduction in stature. The thickening of the neural arch leads to a reduction in the calibre of the vertebral canal which may reach a sufficient degree to give rise to evidence of spinal cord compression.

In the Long Bones the disease manifests itself by the wholesale removal of the original osseous framework by a growth of vascular connective tissue. In the earliest stages the vascular connective tissue pervades both the spongy bone and the ivory bone of the cortex, the latter from patchy absorption becomes porous and trabeculated. It becomes thickened from the bulk of the connective tissue and the distinction between compact and cancellous bone is completely lost. The periosteum is normal. The thickening of the bone leads to irregularity on the surface while internally it may lead to considerable reduction in the size of the medullary cavity. As the old bone is progressively resorbed the connective tissue infiltration demonstrates

osteogenic properties, and bone absorption and deposition may thus proceed simultaneously. Ultimately ossification becomes more active, and the enlarged bone is converted into hard, heavy, and apparently strong osseous tissue. In the stage of softening and enlargement the bone is apt to become deformed—partly because the soft bone yields to normal gravitational weight-bearing or muscular stresses, and partly, in the forearm and leg, by the fact that one bone may be more involved than its neighbour, and tends to become bent towards it.

THE HISTOLOGY OF THE PROCESS

In the early stages of the disease there is a diffuse infiltration by young granulation tissue and the trabeculae of the bone are attenuated. The Howship's lacunae are enlarged and occupied by granulation tissue cells or osteoclasts. In the stage of osteogenic activity the sections show numerous trabeculae of new bone. These are elaborated from the connective tissue and are irregular in their distribution. They are so numerous that adjacent struts may fuse to enclose an irregular space or lacuna containing connective tissue. These are sometimes erroneously called new Haversian systems. Areas apparently of gelatinous degeneration of the connective tissue may be present—these are undoubtedly the cysts observed occasionally on radiological examination.

BLOOD CHEMISTRY IN OSTEITIS DEFORMANS

In this disease the serum calcium and the serum phosphorus are usually normal, but there is a very high plasma phosphatase content. This, however, is by no means specific, for it is a feature of most of the rarefying diseases of bone, and according to Taylor is not related to the cause of the bone disturbance, but is a result of it. He suggests that absorption of bone stimulates osteoblastic activity, but the phosphatase is promptly swept into the blood stream, where it is progressively destroyed.

The excretion of calcium and phosphorus is on rare occasions increased.

ETIOLOGY

The origin of osteitis deformans is not known. Paget's original suggestion was that the disease was inflammatory in origin, and later a possible association with syphilis was postulated. Lawford Knaggs, in an excellent account of the disease, held that it most likely had a toxic basis, the origin of the toxin being in the gastro-intestinal tract, and the nature of it metabolic. He thought that osteomalacia, osteitis fibrosa cystica and osteitis deformans were different reactions to a similar type of toxæmia. Belden held a similar view, and suggested that if the toxæmia was sufficient to overcome the individual resistance in childhood, osteitis fibrosa cystica resulted, if sufficient resistance was present to stave off effects till middle life, then, as the constitutional strength became lowered by age, intercurrent disease or arteriosclerosis,

Paget's disease might supervene. The osteomalacic form arose when bad hygienic conditions, repeated pregnancy, or some intercurrent disease accentuated the effects of the toxæmia.

There is now sufficient proof to negative these views, for the relationship of osteomalacia to rickets is well established, while it is generally agreed that osteitis deformans is an entity distinct from the generalized fibro cystic dystrophy.

It has of late been suggested that the disease results from hyperparathyroidism. Cases of parathyroid osteodystrophy presenting several of the features of Paget's disease, and showing a disturbance of blood calcium and phosphorus content, have been reported, amongst others by Allbright. The latter observer has suggested that the explanation of this lies in the fact that the hyperparathyroidism will exaggerate or activate the unknown factor of Paget's disease. The occurrence of Paget's disease along with the blood changes of hyperparathyroidism, therefore, is not to be regarded as cause and effect, but as coincidence. Beattie states that the only experimental reproduction of Paget's disease has been by the prolonged administration of small doses of vitamin D. The trabeculae of the bone are gradually appropriated and the calcium is transferred to the cortex. In review, therefore, it may be taken that the inflammatory nature—specific, bacterial, or otherwise—and the toxic nature of osteitis deformans are not likely. The disease is not related etiologically to parathyroid osteodystrophy or osteomalacia, and when it is associated with alteration of serum calcium or phosphorus, this is coincidental, while its relationship to vitamin D excess requires further proof.

The DIAGNOSIS is made plain in the table (p. 156).

TREATMENT

No curative treatment of Paget's disease is known and the most that can be done in the usual case is to relieve the pain. Radiotherapy is of considerable benefit in alleviating the bone pain. A diet low in calcium and phosphorus and high in magnesium has been found to be beneficial by A. B. Gill. The magnesium is given as carbonate in doses of 4 to 10 grammes per day. Pain and local tenderness are relieved, and the bones show a decrease in density and diameter while blood phosphatase also diminishes.

PARATHYROID OSTEODYSTROPHY

A decade ago there was no proof of the relationship between parathyroid activity and the metabolism of calcium and phosphorus. The discovery of the parathyroid hormone placed in our hands the explanation of generalized osteitis fibrosa of von Recklinghausen (Hunter). It has now been shown, in more than eighty-two cases, that in the latter disease there is almost invariably a profound disturbance of calcium metabolism and a parathyroid tumour, the removal of which brings

about amelioration in the symptoms of the disease. There has been a tendency in the past few years therefore to employ the term von Recklinghausen's disease or generalized fibrocystic disease as synonymous with hyperparathyroidism. For reasons which will become apparent there is some evidence that this is not absolutely correct. The term parathyroid osteodystrophy suggested by Struthers has been employed here. Struthers has very succinctly defined the present day position in these words: "a definite clinical and pathological entity exists in which the growth of a simple parathyroid adenoma is apparently the cause of progressive decalcification of the skeleton attended by secondary degenerative changes in the bones and profound general debility leading in the absence of appropriate treatment to a fatal result."

CLINICAL FEATURES

The disease may affect either sex but is more common in women. The majority of cases occur in the third, fourth and fifth decades but it has been observed as early as fourteen years of age and as old as sixty. No predisposing causes are known.

The most common initial feature is increasing severe pain and tenderness in the bones especially felt in the lower limbs and back. Sometimes at the beginning one bone alone is affected. Usually the pain is associated with general weakness and accompanied by pallor and debility. Hypotonia and muscular weakness are common.

Often the next event is a fracture from trivial injury. The fracture takes a long time to heal but eventually unites often in a position of deformity. In the absence of fracture pain becomes continuous and generalized. The limbs become grossly deformed till the patient is bedridden.

Occasionally the development of a tumour—in the maxilla or the mandible—may be the earliest evidence while occasionally fracture is the earliest sign or general asthenia may initiate the disease and be far advanced before the bone changes become apparent.

Anorexia and nausea, vomiting and abdominal cramps are common and occasionally attacks of renal colic with hæmaturia occur due to the development of a renal calculus.

RADIOLOGICAL FEATURES

The radiological appearances consist chiefly of irregular diffuse rarefaction with absorption of the compact bone and cyst like degeneration.

In the skull the bones show a well marked stippling but the opaque areas are small—pinhead in size according to Brunsford—which serves to distinguish them from the grosser mottling of Paget's disease.

The vertebrae are less dense and show central collapse. The upper and lower surfaces are concave and the intervertebral discs are correspondingly swollen.

The pelvis shows coarse striations amongst which large clear cyst like spaces are usually visible.

The femur shows loss of trabeculation. Deformity is common—coxa vara bowing, and cyst-like spaces may be present at the extremities and in the middle of the shaft. Over the cysts the bone may show a slight fusiform enlargement, but nothing is found comparable to the cortical expansion over a giant celled tumour. Similar appearances are found in the other long bones, and in the short long bones of the hand and foot.

One further radiological feature is present in a number of cases—the presence of extra osseous calcium deposits. These most usually take the form of renal calculi, salivary, biliary or pancreatic calculi.

THE PATHOLOGY OF PARATHYROID OSTEODYSTROPHY

The Skeletal Changes In brief, the bone changes consist of progressive absorption and softening of the bones due to increased osteoclastic activity, together with a certain measure of new bone replacement—osteogenesis. Two other features call for notice—the occurrence of collections of giant cells (osteoclastomata) and the formation of cysts.

The Softening and Absorbing Process This is the most obvious and striking change, and may proceed until the bone is converted virtually into a fibrous tissue cylinder, which cuts easily but feels gritty from the presence of scattered spicules of newly formed bone. The girth of the affected bone is usually increased, but the periosteum is normal. Deformity is usually present due to the effect of gravity, weight-bearing, or muscular action on the softened bone. When

FIG. 67—Osteitis Fibrosa Cystica of the Tibia

the bone is sectioned vascular granulation tissue is seen to occupy it from end to end and the cortex is thin and spongy in texture. The cancellous tissue of the ends may be practically replaced by the connective tissue.

Histologically the significant change is the widespread degree of

big irregular spaces lined by a zone of osteoclasts lying in lacunae in close apposition to the bone they are eroding. The spaces are filled with vascular tissue with many capillaries and endothelial cells and as the bone is destroyed spindle shaped fibroblasts appear. Adjacent spaces eventually come to communicate with each other as the bone between them is removed and as the amount of fibrous tissue increases *pari passu* with the bone removed the capillaries are slowly obliterated.

The New Bone Formation In the mass of fibrous tissue spicules of new bone are formed first by metaplasia from the connective tissue. On the original spicules osteogenic cells derived from the connective tissue become ranged in successive rows and secrete successive layers of extracellular mucinous matrix. If this matrix becomes calcified laminated bone results. Often the calcification is poor and the layer of matrix is then only an osteoid tissue lamella.

The Giant Cell Areas Macroscopically these vary from large reddish brown masses to minute foci. Microscopically they are composed of masses of giant celled osteoclasts in a matrix of connective tissue. The distribution of the giant-cell areas is of some significance. They are arranged in clusters round areas of haemorrhage or in relation to unabsorbed bony spicules and their cytoplasm frequently contains red blood cells and haemosiderin.

The Cysts The cysts vary in size but may be as large as a plum. They contain a thin brownish fluid and are apparently formed by the liquefaction of the connective tissue.

The cysts in the giant cell areas when common or large seriously weaken the bone and render it specially liable to fracture.

THE CHANGES IN THE BLOOD CHEMISTRY

According to Albright hyperparathyroidism in its active phase is unique in producing a high serum calcium together with a low serum phosphorus. The calcium estimate varies from 11.5 to 23.6 mgms per 100 c.c. and the phosphorus from 3.6 to 1.0 m.c.ms per 100 c.c.

The excretion of calcium and phosphate in the urine is augmented while the serum phosphatase is high.

The Parathyroid Adenoma It has been demonstrated by Turnbull that the parathyroid enlargement is not neoplastic but of the nature of a functional over activity. Usually one of the four parathyroids is affected but on several occasions two have been the site of change.

Metastatic Calcium Deposits Metastatic calcification is common in parathyroid osteodystrophy the commonest site being the arteries lungs kidney and stomach wall. Renal calculi are also prone to occur. The metastatic deposits are of interest in that unlike the calcification which occurs in diseased tissues they occur in healthy cells.

The Origin of Parathyroid Osteodystrophy The relationship

between the disturbances of the parathyroid gland and the bone changes is now completely proved by clinical and experimental evidence. Removal of the overfunctioning parathyroid leads to a dramatic arrest of the disease, while the prolonged administration of parathormone—the active principle of the gland—leads to skeletal changes, metastatic deformity, and disturbance of the blood chemistry in no wise differing from those occurring in the disease. The bone effects, then, are due to the circulation of an excessive amount of parathormone.

The Action of the Parathormone is to disturb the calcium phosphorus ratio in the serum. It stimulates the excretion of phosphate so that the serum phosphate falls and the serum calcium rises, as calcium phosphate is mobilized from the bones. The excess of calcium is excreted along with the phosphate in the urine, more calcium phosphate is dissolved from the bones, and so a drain on the calcium phosphate of the skeleton is established. It is probable that large doses of parathormone also act directly on the bone as well as through the phosphate mechanism. The direct effect is most likely to stimulate the osteoclastic activity.

The Cause of the Hyperparathyroidism is not known. Arguing from analogy with hyperthyroidism, it is likely that the stimuli producing parathyroid hyperfunction can be derived from many and varied sources.

The Nature of the Bone Changes. Jaffe and Bodansky were the first to reproduce experimentally the features of parathyroid osteodystrophy by parathormone injections in rabbits. Taylor in this country, however, has afforded us the most illuminating account of the skeletal changes. It appears that in the stage of decalcification, the rapid removal of calcium is attended by marrow hæmorrhages, probably as a result of damage to the capillary endothelium from the local concentration of calcium in the capillary vessels of the bone. It is only after the occurrence of the hæmorrhage that the connective tissue proliferation, and the giant cell increase are found, and Taylor suggests that they are both reactions to the damage caused by the marrow hæmorrhages.

The Formation of Urinary Calculi is due to the increased excretion of calcium and phosphate in the urine. The calculi may be formed in the pelvis or in the collecting tubules, actually in the parenchyma. They lead to sclerotic changes in the kidney. Allbright points out that if the disease is of short duration and the amount of calcium in the diet is high, the bone changes may be later in appearing, but the formation of urinary calculi is an early feature. In long standing disease, with low dietetic calcium, the reverse obtains.

The Diagnosis of Parathyroid Osteodystrophy depends on the demonstration of the hypercalcaemia and hypophosphæmia in association with the characteristic bone changes. It must not be forgotten, however, that in some cases the initial feature to attract attention is a lesion

other than the skeletal one—i.e. the occurrence of urinary calculi. In multiple and recurrent urolithiasis therefore it is desirable to investigate the plasma content of calcium and phosphate.

DIFFERENTIAL DIAGNOSIS

The conditions affording most difficulty are those where—focally or generally—there is radiological and histological similarity to osteitis fibrosa but without the disturbance in the plasma calcium and the plasma phosphorus. Hunter is insistent on the point that in the absence of serum changes it is not justifiable to explore the parathyroids as in his opinion these disturbances cannot be regarded as the product of over function of the parathyroid glands.

Many conditions reproduce certain of the clinical features of parathyroid osteodystrophy but the majority of these—gout, constipation, low back pain—have no radiological evidence of bone disturbance. Certain general bone diseases also bear an occasional or a superficial resemblance to fibro cystic disease. Some of these are considered below.

Senile Osteoporosis. In this condition—it is hardly a disease—the texture of the bone is quantitatively rather than qualitatively reduced i.e. its lime content only is depleted. This is partly the effect of diminished use and partly of diminished activity—senility—on the part of the osteogenic tissues. The blood calcium is normal and the age of onset is late in contra-distinction to fibrocystic disease. Nevertheless the tendency to fracture, deformity and bone pain may lead to some confusion and the radiographic bone changes are not markedly dissimilar to the changes of the milder forms of hyperparathyroidism.

In **Osteitis Deformans**, the occasional occurrence of cysts, the histological resemblance and the occasional occurrence of hypercalcaemia may render it difficult to distinguish from parathyroid osteodystrophy. The radiological appearances, the age of onset and the absence of blood changes will lead to a correct diagnosis in the majority of cases. Where there is alteration in the blood chemistry it is likely as Albright suggests that there is a super added element of hyperparathyroidism and the two are not to be regarded as cause and effect.

Osteomalacia. In this disease the characteristic circumstances—starvation, poverty, diet, pregnancy—together with the fact that there is bending of the bones rather than fracture, that the blood calcium and phosphorus are low and that there is a rapid response to vitamin D therapy should make the diagnosis clear.

Osteogenesis Imperfecta. In the so called adult form of fragilit osseum there should be no difficulty in diagnosis. The disease has persisted from childhood, there is a history of multiple fractures, the sclerotics are usually blue and the individual is dwarfed. The blood chemistry is normal, and the radiological picture characteristic.

Multiple Myeloma. The radiological appearance of multiple myeloma may simulate closely the appearance of parathyroid osteo-

POINTS IN DIFFERENTIAL DIAGNOSIS BETWEEN HYPERPARATHYROIDISM AND OTHER BONE DISEASES (after ALLBRIGHT)

| Disease | Differential Points as Regards | | | Serum | | Plasma 1 hour after | Miscellaneous |
|---|--|--|--|-------------------------|-------------------------|----------------------------------|--|
| | any appearance | any appearance | Weggs | Calcium | 1 hour before | | |
| Hyperparathyroidism with bone involvement | Bony deformity in our polynoma those related to stones | Increased radiolucency generalized cysts tumours fractures stones | Rarefied bone fibrosis of marrow osteoclasts +++ osteonal tissue only slightly increased osteoblasts +++ | High | Low | High | All 500 groups |
| Benign osteoporosis | No bony tumours polynoma or stones | No cysts tumours or stones | No fibrosis of marrow osteoclasts normal osteonal tissue normal or decreased osteoblasts decreased | Normal | Normal or low | Normal | Old age |
| Paget's disease | Bony enlargement polynoma stones in fragment | Polycystic but not generalized bony atrophy enlarged thickened skull | May occasionally be difficult or impossible to differentiate | Normal or slightly high | Normal or slightly high | Very high | Bone in families, predilection for weight bearing bones, seldom seen under 40; arterio sclerosis ++ + Practically absent in this country except with fatty diarrhoea |
| Osteomalacia | No bony tumours polynoma or stones | No tumours or stones finding deformities ++ + | Osteon tissue ++ + osteoblasts ++ + osteoclasts decreased | Normal or low | Low | High | |
| Solitary cysts | Confined to cysts | No generalized changes cysts may be multiple | Cannot differentiate if taken from lesion | Normal | Normal | Normal | |
| Solitary benign giant cell tumour | Confined to tumour | No generalized changes | Cannot differentiate if taken from lesion | Normal | Normal | Normal | |
| Osteogenic sarcoma | Fractures ++ + no bone tumour polynoma or stones | Cysts rare, no tumours or stones | No fibrosis of marrow osteoclasts normal | Normal | Normal | Normal or very slightly elevated | Hereditary often coupled with deafness, improves after cessation of growth Deuce-Jones protein urine |
| Multiple myeloma | Can cause same bony symptoms and radiological appearance | Can be almost indistinguishable | Tumour tissue | Normal or high | Normal or high | Normal | |

dystrophy, especially in the collapse of the vertebrae the occurrence of punctate areas of diminished density in the skull and long bones and fine mottling of the pelvic bones. The blood calcium phosphorus ratio is as a rule normal while in abnormal protein—the Bence Jones proteose—may appear in the urine. Biopsy may be demanded.

PROGNOSIS AFTER OPERATION

After parathyroidectomy the prognosis is good. Hunter finds in the majority of cases that the bone pains are immediately abolished. There is usually a marked gain in weight and crippled individuals have even been able to dispense with sticks and crutches.

Some authorities also claim that removal of the parathyroid swelling is followed after some months by increased density of the bone shadow on radiological examination.

TREATMENT

In the presence of generalized *osteitis fibrosa* the neck should be explored for parathyroid tumour even in the absence of a palpable swelling.

A wide exposure should be aimed at for Walton points out that it may be necessary to continue the search behind the trachea or down into the mediastinum.

Normally there are at least two parathyroid bodies on each side, and in some individuals there may be three or four. The superior bodies though variable in their lateral and vertical position are usually situated between the pretracheal fascia and the posterior part of the capsule of the thyroid gland.

The inferior bodies although usually described as also lying between the fascia and the thyroid capsule, may lie below the inferior thyroid artery and beneath the pretracheal fascia. In this case they are only visible from the posterior surface or after division of the fascia.

The enlarged parathyroid has a characteristic yellowish brown appearance which renders it distinctive even to the naked eye.

After operation a diet rich in calcium should be arranged while ultra violet radiation is a useful procedure. Convalescence is frequently associated with tetany, but this may be controlled by administration of calcium gluconate irradiated ergosterol and parathormone.

Orthopaedic treatment is directed merely towards the adequate protection of the softened bones from all deforming stresses and strains.

After the disease has been arrested and recalcification of bone occurs, the established deformity may be corrected by the usual means e.g. osteotomy.

If for any reason a cervical exploration is contra indicated treatment should consist of the prevention of deformity, the exhibition of irradiated ergosterol to increase the deposition of bone and such general measures as are rendered necessary by the patient's wasted condition.

OTHER VARIETIES OF FIBRO CYSTIC DISEASE IN BONE

1 Osteitis Fibrosa Juvenilis Chronica (Diffuse fibrosis of bone)

Under this title Struthers has drawn attention to a condition in which bone changes and radiological appearances akin to those of generalized parathyroid osteodystrophy make their appearance in early childhood, and persist into adult life. Fractures and deformities occur but there are none of the systemic disturbances of the hyperparathyroid lesion, and the blood content of calcium and phosphorus is not disturbed.

The disease according to Elmslie has a special predilection for the upper part of the femur and for the tibia, but changes may also be found in the humerus, fibula, metatarsals, metacarpals, phalanges, pelvis and skull. The X-ray examination shows expansion of the bone and disappearance of the cortex and medulla. The diseased area is sharply delineated from the normal bone. Elmslie has investigated the pathology of these cases and has shown that the bone is replaced by dense fibrous tissue containing numerous fragments of bone. Osteoclastic activity is marked in proximity to the bony fragments.

DIAGNOSIS The characteristic onset in childhood or adolescence, the somewhat atypical radiological appearance, and the absence of biochemical disturbance, serve to make this a recognizable entity which can be separated from parathyroid osteodystrophy.

TREATMENT Apart from the correction of deformity, no further treatment is at present recommended.

2 Localized Fibrosis of Bone

Elmslie has shown that a disease, comparable to the above, may affect a single bone, usually the tibia or femur. Its pathology is similar to the generalized form, and clinically it occurs or appears, in childhood leading to deformity.

3 The Bone Cyst (Focal osteitis fibrosa cystica)

A solitary bone cyst may appear in one of the long bones again during childhood or adolescence. It, too, is distinguished by the fact that there is no disturbance of the serum calcium, so that parathyroidectomy is not called for.

PATHOLOGY The cyst, according to Elmslie, is formed by lacunar absorption of bone by osteoclasts. Its wall is composed of a thin shell of bone and occasionally soft reddish cellular tissue is found at its margin. Sometimes it has a patchy fibro-membranous lining. The cyst usually contains a small amount of brownish fluid. The marginal cellular tissue, when present, contains numerous giant-celled osteoclasts—to this variety Elmslie applies the term *osteoclastomatous cyst*, and he points out that if this osteoclastomatous tissue is examined by itself the lesion would be called a benign giant-celled tumour.

The lesion may occur in any of the long bones, but is especially common in the upper end of the femur and the upper end of the humerus. It is situated in the cancellous tissue of the metaphysis.

ETIOLOGY The origin of the cyst is not known. It is interesting to recall however that Taylor, Jaffe, Bodansky and Kolodny have all shown that the occurrence of cysts and areas of increased giant celled activity are not specific to any one bone dystrophy but appear as reactive phenomena after marrow hemorrhage.



FIG. 68.—Osteitis Fibrosa Cystica.
Proximal fracture of the femur.

Although often known as *focal osteitis fibrosa cystica*, the title is only an indication of the pathological findings and not of the cause of the disease. Certainly it has no connection with generalized parathyroid osteodystrophy.

CLINICAL FEATURES The cyst appears insidiously during the first or second decades. At first there is little or no discomfort or other indication of its presence save a localized swelling. Occasionally spon-

taneous fracture is the first indication of its presence and sometimes the occurrence of fracture leads to spontaneous healing of the cyst

RADIOLOGICAL FEATURES

In the presence of a solitary cyst the bone is irregularly broadened the cyst shows as a symmetrical area of greatly diminished density in the metaphysal area and bone structure may even be entirely lacking

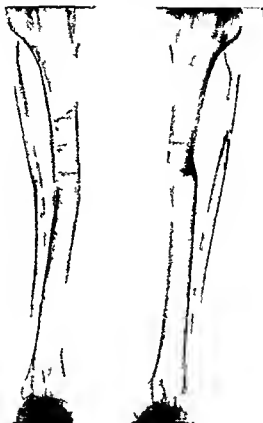


FIG. 69.—Thyrotoxic Osteoporosis

The leg bones of a case of thyrotoxicosis showing extreme porosis with pathological fracture (W. W. Wasson)

The bone cortex is expanded to form a thin shell overlying the shaft. At its distal end the cyst may be continued as a pointed extension of the shaft thus differing from many other cystic conditions of bone, e.g. giant celled tumour where the lower border is rounded.

DIFFERENTIAL DIAGNOSIS Cyst formation occurs in many diseases in addition to osteitis fibrosa cystica. Bloodgood states that they may be found in multiple chondroma myxoma benign giant cell tumour osteitis deformans sub periosteal hæmatoma and ordinary callus.

In addition certain inflammatory conditions should also be excluded—tuberculous osteitis specific osteitis and Brodie's abscess.

PROGNOSIS The solitary cyst displays a marked tendency towards spontaneous healing should a fracture occur before this is accomplished the resulting reaction will usually initiate the process.

TREATMENT Healing may take place without surgical intervention but the process is slow and apt to be associated with later weakness of the bone or with deformity.

The cyst should be thoroughly curetted and the resulting cavity filled up with bone chips or by a single massive bone graft.

Thyrotoxic Osteoporosis

In thyrotoxicosis there is a marked increase in the general metabolism. Its effect on bone and its structure is less well known and understood. In hyperthyroidism the serum calcium and phosphorus are normal but there is exaggerated excretion sometimes to as much as eight times the normal. In association with this the bones undergo very marked rarefaction through the agency of increased osteoclastic activity and eventually become so weak that spontaneous fractures occur. Apart from definite fractures deformities may arise from weight-bearing or from muscular action. Thus kyphosis or scoliosis and pelvic asymmetry may be present. Deformity is less common in the long bones.

The cause of the increased excretion of calcium is not known but Hertz has shown that the calcium excretion and skeletal rarefaction are greater after the administration to animals of the thyrotropic factor of pituitary secretion than after equal amounts of parathyroid. And it may be that the effects on the calcium metabolism are due to simultaneous stimulation of the parathyroid glands by this pituitary hormone.

THE PITUITARY DISTURBANCES

The pathogenesis of the skeletal changes in pituitary disease is closely connected with the function of the cells composing the anterior lobe of the pituitary body. Normally two varieties of cell can be distinguished. In one—the chromophobe cells—the cytoplasm is granular while the other variety—the chromophil—contains large coarse granules. The granular chromophil cells are further differentiated by staining reactions of the granules. Thus those that take up the basophilic dyes are known as oxyphil or eosinophil cells. The term basophil is applied to those with an affinity for the basic dyes.

Modern experimental work has assigned specific functions to the different cells. Thus the acidophil cell is regarded as concerned with skeletal growth, the basophil cells with the development and maintenance of the sexual and reproductive apparatus.

Skeletal disturbances may be produced as a result of either a diminution or an excess of the growth factor of the eosinophil cells.

Excessive secretion leads to—

(a) **Giantism**, when the process occurs before the epiphyses have united with the shafts of the long bones

(b) **Acromegaly**, when it occurs later in adult life

Diminution in secretion leads to—

Dwarfism

The Pituitary Dwarfisms

The term dwarf is applied to an individual whose physical dimensions are considerably beneath those peculiar to his race. It is often extremely difficult to assign the responsibility for dwarfism to any particular organ but in the case of the pituitary types there are often other features

There are two main types

(1) *Froehlich's adiposo genital type* in which skeletal stunting is associated with general obesity genital hyperplasia and often stupidity or idiocy

(2) *The Laron type* in which there is no mental or other change, but only lack of skeletal growth. Such individuals remain it has been said attractive and graceful children

THE SKELETAL CHANGES

The growth of all parts of the skeleton is delayed or arrested. The epiphyses remain ununited for a prolonged period and the metaphysis terminates in a line of dense bone. The histological change is an absence of division of the cartilage cells in enchondral bone and absence of division of the primitive connective tissue cells in the membrane bones

ETIOLOGY

The usual cause of hypopituitarism is a tumour or cyst (suprasellar cyst) compressing and destroying the gland. In some cases where the dwarfing is already present at birth there is said to be an aplasia of the gland or a failure of differentiation of the eosinophil cells

THE HYPERPITUITARY SYNDROMES

Giantism

This condition begins before the epiphyses have been fused with the shaft and the growth of the skeleton is speeded up and becomes excessive. There is also thickening of the skull bones and of the jaw. The mental development is subnormal and the body strength often surprisingly slight

In the majority of cases some of the features of acromegaly develop later

PATHOLOGY

The bones of the skeleton show increased thickness and length; the skull and other membrane bones are also hypertrophied.

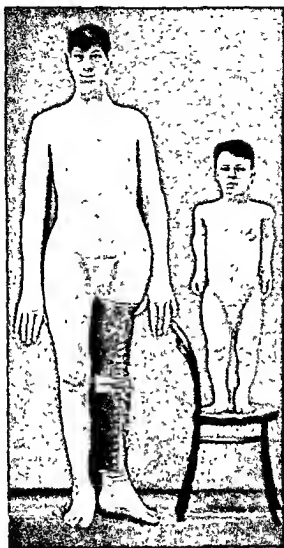


FIG. 70.—Achondroplasia and Acromegaly.
These two lads were great friends.

HISTOLOGICAL FEATURES

At the epiphyseal cartilage growth of the cartilage cells is active, but the orderly palisade arrangement is lost, the cells being arranged in irregular groups. The amount of matrix is increased. The number of vascular buds and the number of advancing osteogenic mesenchymal cells is increased, so that osteogenic activity is maximal.

In the sub periosteal area as in the membrane bones the osteogenic cells show increased proliferation and there is rapid new bone formation. The layers of bone may be more irregular as well as more numerous than normal.

Acromegaly

The manifestations of acromegaly appear after skeletal growth has normally ceased and the disease is characterized by an unevenly distributed exaggeration of ossification. Lawford Knaggs has recently made a comprehensive study of the disease and attributes the irregular distribution of the process to the effects of local pressure and traction.



FIG. 71.—Acromegaly showing large hands and big face with thick lips.

ETIOLOGY

Acromegaly is due to the circulation of an excessive amount of the growth factor of the eosinophil cells of the anterior lobe of the pituitary. There is either a hyperplasia of these cells or else a tumour—eosinophil adenoma—composed of these cells.

PATHOLOGY

The Skeletal Changes There are deposits of porous bone in the alveolar margins of the jaws leading to great elongation of the face and projection of the chin. The ramus of the jaw is narrow

and elongated. The maxillary bones are also the site of a similar deposition and the vault of the skull may be thickened. The skull change begins or is most marked in the frontal bone and the deposits occasionally take the form of osteomata growing from the inner table of the skull. The foramen magnum is usually displaced forwards and the pituitary fossa enlarged from the presence of the mass or adenoma of hyperplastic eosinophil cells.

The thorax is massive due to the increased length of the ribs which is partly the result of the exaggerated bone growth and partly the result of the hypertrophy of the lungs.

In the long bones the most obvious changes are found towards the extremities which are more massive than normal and less well modelled. Muscular insertions and tuberosities and ridges are usually accentuated. Sometimes the bones are longer and thicker.

The short long bones are thick and usually elongated. Muscular and tendinous insertions are again prominent and at the articular end slipping may be pronounced.

The changes in the vertebral column consist of deposits of new subperiosteal bone which is thickest on the anterior surface of the body and gradually tapers off as the body is triced round to the vertebral canal. This phenomenon is occasionally referred to as acromegalic spondylitis. Cervicothoracic kyphosis is common and according to Knaegs is the result of an associated muscular hypotonicity.

In the late stages of acromegaly bone atrophy may replace the hypertrophy of the earlier phases.

Acromegalic Arthritis may affect any of the limb or spinal joints and Knaegs draws attention to an important point in the pathology of it. In the ordinary varieties of osteoarthritis the earliest change consists of attenuation and ultimate disappearance of the articular cartilage at the points of greatest pressure between opposing articular surfaces. In the acromegalic form a similar effect is obtained by a different means for the earliest change is in the subchondral bone. As nodules of new subchondral bone are deposited they tend to be pushed up into the deeper layers of the cartilage and the cartilage is progressively thinned by pressure from below until the bony nodule is exposed. The ulcer of the articular surface so produced is said characteristically to show undermined edges until these are worn away by friction. When this occurs the acromegalic arthritic lesion is indistinguishable from ordinary osteoarthritis.

The Histology of the Process is simple consisting as it does of the deposit of additional layers of subperiosteal bone and of new bone along the lamellæ of the spongy bones. Knaegs believes that the osteoblasts are rendered hypersensitive and hyperactive by the pituitary hormone. The patchy nature of the lesions is due to the fact that the hypersensitive osteoblasts deposit new bone at points where traction is applied by muscles or tendons, or where pressure is applied as in

standing or walking. The jaw changes are said to result from the intermittent pull on the jaws during mastication.

Congenital Hypothyroidism (Cretinism)

When the thyroid gland is completely absent (athyrosis) or is destroyed in early infancy by disease cretinism is produced. There may or may not be an enlargement of the gland depending on the nature of the defect.

The prominent features of cretinism are

- 1 Signs of mental deficiency
- 2 Anomalies in genital development
- 3 Disturbance of growth

The last is the most obvious and constant evidence. The cretin is a dwarf. The long bones are short while the ossification of the skull is delayed and the fontanelle closes late—as late sometimes, as twenty years. The root of the nose is depressed from defective growth of the base of the skull. The vault of the skull may appear large in comparison with the body. Apart from these features the growth of the cretin is fairly proportionate.

THE NATURE OF THE SKELETAL CHANGES

The principal skeletal changes are the late appearance of the epiphyses and of bones whose ossific nuclei develop after birth e.g. the carpal and the tarsal bones and the delayed union of the epiphyses. Indeed the epiphyses may remain separate from the shaft well into adult life. Despite this growth is largely in abeyance ultimately fusion takes place.

RADIOLOGICAL APPEARANCES

The distinctive interference with the ossification process is of course apparent. In addition the shafts of the long bones appear short with a thick cortex but their calibre is diminished. Towards the extremities of the bones the size approximates more nearly to normal. The epiphyses are not only late in appearing but small and often irregular in ossification so that they appear fragmented and show a superficial resemblance to osteochondritis.

There may be delay or arrest in fusion between the two halves of the neural arch or the neuro-central synchondrosis while disturbance of normal ossification of the vertebral bodies is common.

THE PATHOLOGY OF THE BONE CHANGES

The nature of the bone error is simple. There is an arrest of both enchondral and subperiosteal new bone formation. This is due not to lack of calcium for this is often in excess in the zone of calcification but to arrest of the proliferation of the cartilage and to arrest of osteoblastic activity.

The other features the genital hypoplasia and the idiocy do not concern us here.

TREATMENT

The administration of thyroid extract is curative if treatment is begun in infancy. It is interesting to note that since epiphyseal fusion is delayed the administration of thyroid may produce growth in stature even in the adult.

THE RETICULO-ENDOTHELIAL DISTURBANCES OF BONE

The cells forming the lining of the minute blood vascular channels of the bone marrow are part of the reticulo-endothelial system and possess in common with the other members of this highly important system powers of considerable activity. The other cell elements of the system are certain adult connective tissue cells (fibrocytes) the endothelium lining blood and lymph vessels the reticulum cells of the spleen and certain of the large mononuclear cells of the blood.

The functions of the reticulo-endothelial system are as yet imperfectly known but its cells are typically the scavengers of the body and their activity is concerned mainly with the removal from the circulating fluid of dead and damaged cells bacteria and other foreign or noxious material. It is also energetic in the disposal of such metabolic substances as hæmoglobin and cholesterol.

The reticulo-endothelial tissue of bone is—from the nature of it—mainly congregated at the ends of the long bones and in the spongy bone of the flat and short bones and it most likely shares in the affections to which the system elsewhere is liable. Despite this bone changes have been specifically described in connection with only two of the disorders of the reticulo-endothelial system—

- 1 Lymphogranuloma (Hodgkin's disease)
- 2 Lipoid granulomatosis

The Bone Changes of Hodgkin's Disease

Autopsy records show that involvement of the bone marrow in Hodgkin's disease is more frequent than clinical studies would lead one to suspect though in the majority of recorded cases the bone lesions have become evident some time after the clinical recognition of the disease elsewhere. Thus in the case of Gage the characteristic appearance was discovered accidentally through the inclusion of the shoulder in a control X-ray of the chest. The appearance was so suggestive of a neoplastic condition that biopsy was carried out and revealed the characteristic histopathology of lymphogranuloma.

PATHOLOGY

The Locus of the Disease in Bone. The vertebral column and pelvis are the bones most often involved. In the vertebral column the bodies of the lumbar vertebrae are the most liable. The cancellous tissue of the upper end of the femur is also a common site. Of

the other bones, the diploe of the skull, the ends of the tibia, the lower end of the femur the ends of the humerus are less commonly affected

In the cancellous tissue of the affected bone there develops an infiltrating mass of tissue displaying the characteristic histology of Hodgkin's disease. The effect on the neighbouring bone is largely coincidental, the cancellous struts are destroyed and the overlying cortex progressively removed. The reaction of the bone adjacent to that undergoing osteolysis varies with the situation. In the vertebrae the destruction is usually so extreme that collapse of one or more of the bodies occurs. In the pelvis, areas of rarefaction are surrounded by areas of sclerosis while in the skull the infiltration is predominantly osteolytic. In the ribs, complete destruction of the affected segment is the rule. In the long bones there is often sub periosteal new bone formation which may be so marked that the lesion resembles chronic osteomyelitis and is at least definite enough in some cases to simulate a bone cyst. In other cases the lesion resembles sarcoma.

CLINICAL FEATURES

The bone lesions may appear at any time during the course of the disease and are apparently quite independent of the exact site of origin of the lesion. It is more than likely that subsequent investigation will show that in some cases the condition actually originates in the bone. The sexes are equally liable and age bears no relationship to the severity or the frequency of the bone changes. In more than half of the recorded cases pain was the first indication of the osseous spread. Indeed, in not a few instances radiological evidence was delayed for weeks or months or years after the occurrence of the original pain. On the other hand the bone changes are sometimes discovered accidentally.

The pain is of a dull aching or lancinating character and may be so severe as to interfere with the function of the neighbouring joints. In the spine there may be girdle pains and in some cases evidences of cord compression have subsequently arisen.

The bone changes have little or no effect on the constitutional course of the disease.

DIAGNOSIS

Lymphogranuloma of bone is of most interest from the diagnostic point of view though the occurrence of associated swelling of lymphatic glands and spleen and the secondary anaemia should make the diagnosis clear.

TREATMENT

In common with the other lesions of Hodgkin's disease the bone changes appear to respond to X ray therapy. The pain is relieved and in some cases reparative changes appear in the affected bones.

Lipoid Granulomatosis

Disturbances in lipid metabolism may give rise to a specific pathological change in the reticulo-endothelial system in which that part of the system situated in the spongy skeleton may participate. The actual nature of the lipid whose metabolism is deranged varies and so a group of different diseases has been described though in each the underlying mechanism is similar. In Gaucher's disease a lipoprotein of the cerebroside type is at fault. In Niemann-Pick's disease a phosphatid lipid. In Fry-Sachs syndrome a cerebroside protein and in Hand-Christrian-Schuller's disease cholesterol. In all of these bone changes have been reported or observed though the main effects of the disease are wrought on the extra osseous portions of the reticulo-endothelium but it is only in connection with the Hand-Christrian-Schuller disease that the osseous effects have attained a clinical or pathological importance.

PATHOLOGY

Fraser has presented a very comprehensive review of the condition and he suggests that the initial change is one of increased lipid content in the circulating body fluids. As a result of this increase and in an attempt to adjust the balance the reticulo-endothelial cells proceed to absorb and deposit the substance so that accumulation occurs in individual areas. That an excess of cholesterol is the essential factor is borne out by the constancy of the hypercholesteræmia and Fraser suggests that this is the result of a failure on the part of the normal mechanism for maintaining the blood cholesterol content at a constant level. The weight of experimental work appears to suggest that this function is vested in the reticulum of the liver and lungs, though feeding experiments favour the spleen and the lymph nodes as the site of adjustment. It is surmised that a congenital or acquired deficiency in these tissues throws the onus on the reticulo-endothelium elsewhere—especially in bone. Fraser supports Chatalon's observation that there is apparently a threshold to cholesterol and once exceeded the deposits occur simultaneously at different sites in what may be termed a shower. The distribution of the deposits is widespread. In the skeleton the diploe of the skull, the cancellous tissue of the manubria, clavicle, ribs, pelvis and vertebrae are affected. In addition the pleura, the lungs, the liver and the cerebellum have been the site of typical deposits. It is apparent that in the skeleton the lesion though by no means confined to them yet tends to favour bones developed in membrane.

In this situation the deposits appear as multiple circumscribed rounded tumours which characteristically have a golden yellow or brownish yellow colour.

The histology is equally striking. The tumours are composed of large, often multinucleated reticulo-endothelial cells with small nuclei



(a)



(b)

10

Lipoid Granulomatosis showing the Excavation of Bone in the Right Temporal Region (Professor Fraser's case)

and a finely reticulated cytoplasm. The cytoplasm contains for the most part innumerable globules of lipoid which give the cell a 'foamy' appearance. The largest foam cells are found away from the vessels round the vessels are arranged smaller reticulo endothelial cells so that as Fraser has demonstrated the process is evidently one of flow and ebb the cells congregating round the vessels carrying the excess of lipoid being charged and then migrating towards the periphery to make way for others. The presence of the deposits of lipoid excites the production of granulation tissue around the periphery and the granulation tissue may infiltrate widely.

The Effect of the Granulation Tissue on the Bones is to cause destruction of the bone without new bone reaction. In the skull this gives rise to large defects with irregular margins in the midst of which the lipogranulomatous tumours are situated.

The condition in a typical case is well marked on the skull base in the vicinity of the sella turcica. The pituitary gland may be compressed or obliterated and the lipogranulomatous tissue may extend forwards through the superior orbital fissure to collect behind and protrude the eyeball. When the collection is marked in the vicinity of the sella the hypothalamic area of the brain may also be involved. The basisphenoid and the clinoid processes escape.

CLINICAL FEATURES

The disease as originally described consisted of a distinctive syndrome—defects in the membranous bones, exophthalmos and thirst and polyuria (diabetes insipidus). It is to this triad of effects that the term Hand Christian Schuller syndrome is applicable. The exophthalmos is the result of the retrobulbar accumulation of lipoid laden reticulo endothelial cells while the diabetes insipidus is the sequel to the distortion of the hypothalamus.

In an individual case however these striking evidences may be absent until a late stage while in many cases there are further features. Thus interference with the pituitary may lead to retardation of growth and the irritation or tension on the dura mater to irritability and restlessness.

Should the extra osseous reticulo endothelium be affected spleno-megaly or hepatic enlargement may be present and in the latter case jaundice may be observed. The blood shows a cholesterol content which may be raised to as much as 287 mgms per cent.

DIAGNOSIS

The disease although at first sight of little more than academic importance is probably much more common than is realized. The growing number of cases reported in the literature is eloquent witness to this and Fraser's experience that in two cases an erroneous diagnosis of neoplasm was made and in one a mutilating and serious operative procedure advised may well serve to emphasize its clinical

significance Fraser also quotes from the literature the case of a child who underwent bilateral removal of the eye for exophthalmos due to skeletal lipid granulomatosis

The diagnosis should be based on the age of the child and the characteristic triad of clinical features when present together with the demonstration of a high cholesterolæmia In doubtful cases a biopsy may make the decision plain

PROGNOSIS

The disease tends to be progressive and in many published cases death has resulted from asthenia or from the contraction of an intercurrent disease

TREATMENT

The treatment falls naturally into several distinct parts An attempt is made to reduce the hypercholesteræmia by dietetic means Deep radiotherapy is employed to control the deposits while in the event of polyuria and thirst from diabetes insipidus pituitary extract may be exhibited

HETEROTOPIC BONE FORMATION

The occurrence of bone in tissues other than skeletal is an occasional and interesting phenomenon and one whose pathology has given rise to some dispute Such bony deposits are known as heterotopic bone and have to be distinguished from calcification of extra osseous tissues

The deposit of calcium salts in pathological tissues is a common occurrence It may be found in old tuberculous glands in tendons the site of rupture near bone in destructive tuberculous disease of the kidney in the pericardium in the cerebral membranes and in degenerate blood vessels According to Watson Jones and Roberts the deposition of calcium salts in these situations depends on the local concentration of calcium ions and on the activity of phosphatase Phosphatase is an enzyme synthesized by active cells however and it seems most unlikely that degenerate tissues often without the impetus to survive complete destruction would display sufficient biological energy to synthesize this substance A much more likely explanation has been advanced by Herman Taylor who draws a sharp line of distinction between pathological deposits of calcium and bone formation According to Taylor degeneration of certain tissues is associated with the liberation of lipid substances which form calcium soaps and the latter are gradually converted into calcium phosphate and calcium carbonate There is no doubt that in some cases pathological deposits of calcium are converted into bone This has been observed in the kidney but it is a rare and infrequent sequel and its mechanism is then that of heterotopic osteogenesis

Heterotopic Bone has now been reported in a wide variety of

situations—the muscles of the thigh the adductors of the hip (riders bone) in the muscles of the forearm following dislocation of the elbow (myositis ossificans) in the breast in the scar of abdominal section in the tongue etc In the majority of instances it follows trauma In all cases the new bone is laid down in fibrous tissue and a variety of explanations have been vouchsafed to explain the phenomenon It is often claimed that the deposits occur only in tissues in a state of functional death but this is obviously not so when its frequent occurrence in muscular tissues is recalled It has also been suggested that a local deposit of calcium salts precedes the bone formation and in the presence of this the proliferating and undifferentiated mesenchyme acts as an ossifiable medium which may become ossified if a satisfactory blood supply is assured It is thus hailed as an example of ossification without the intervention of osteoblasts

The original conception of heterotopic bone formation was that it was due to osteoblasts carried to the site by the blood stream or derived from local sources—as in the forearm—by rupture of the periosteum and consequent escape of bone forming cells and in abdominal scars from damage to the pelvis or xiphisternum While there are objections to the older view there is an obvious objection to the modern since any tissue which deposits bone may be considered osteogenic and its cells osteoblasts In this connection Herman Taylor has pointed out that the transition of undifferentiated mesenchymal cells into osteoblasts follows the development within the cells of the enzyme phosphatase and such a transition makes the connective tissue cell as much a bone forming osteoblast as the bone forming cells of the original mesenchymal invasion of the primitive cartilage model of the bones of the skeleton It is less confusing therefore to regard heterotopic bone as due to the activity of osteoblasts developed locally from undifferentiated connective tissue

In many of the sites of heterotopic bone however there is no need to postulate even the local development of osteoblasts since breaches of the fibrous periosteal layer will allow the escape of cells of the undifferentiated subperiosteal mesenchymal layer into the tissue planes In either case it is unnecessary to demand as a further requirement a local calcium excess since phosphatase containing cells if they are in contact with the circulation at all can as in developing bone lead to the precipitation of calcium carbonate phosphate

MYOSITIS OSSIFICANS PROGRESSIVA

This rare disease is the most striking of all varieties of heterotopic ossification It is characterized by the progressive development of bone in the muscles tendons ligaments and fasciae of the body and usually begins in childhood during the growth period

The disease is infrequent in this country but appears to have a predilection for the Anglo-Saxon races and it is by no means uncommon

in France Males are more apt to be affected than females in the ratio of 4 : 1

PATHOLOGY

The striking feature of the disease is the replacement of the muscles tendons and aponeuroses by masses of bone mostly attached to the skeletal framework. In some cases masses of bone also lie free in the body of the muscle. Most of the skeletal musculature may be involved but the muscles of facial expression the diaphragm the laryngeal muscles and the tongue escape. Joint capsules may be similarly converted into bone.

The bones of the skeleton may show in association some rarefaction.

The new bone formed may be densely hard or so soft as to cut easily with the knife. If the masses of bone are examined the denser bone is found towards the centre and the softer more spongy bone towards the periphery.

THE HISTOPATHOLOGY

A study of the minute structure of the lesions of progressive myositis ossificans reveals the important fact that the deposits of new bone are not laid down in the actual fibres of the muscle but in the connective tissue between the fibres which later disappear as a result of pressure atrophy. It is this fact that has led Greig to suggest the name fibrositis ossificans progressiva.

Mau has given an excellent account of the pathology. He states that in the earliest stages the interfibrillary connective tissue proliferates and gives rise to a network of embryonic mesodermal tissue which is particularly abundant around the vessels. In this primitive type of connective tissue lime salts are deposited and eventually bone elaborated by the connective tissue cells. Occasionally instead of bone the connective tissue proliferation leads to the formation of a mass of cartilage.

As a general rule when bone formation is about to commence the cells of the proliferated mesenchymal network become small with scanty cytoplasm and dark staining nuclei—i.e. bear a close resemblance to the osteoblasts or osteogenic mesodermal cells which lead to the disposition of bone in the osseous system proper.

These changes are not present at the same stage in all the muscles. The muscles of the back (erector spinae latissimus dorsi) and of the neck are the first to show change but ultimately the disease spreads to involve the major part of the muscular system.

CLINICAL FEATURES

The disease begins in infancy and early childhood and progresses in a series of acute exacerbations followed by remissions of varying duration. During the acute attacks there may be slight evening rise of temperature but this is by no means constant.

The initial feature is the occurrence of a swelling at first soft and fluctuant in relation to one or more of the muscles particularly of the back. The swelling may be tender at first and the overlying skin a bluish red colour. Occasionally the swelling disappears completely more usually it shrinks leaving a hard but small nodule of bone in its wake. During subsequent attacks more and more muscles may be implicated and the deposits in the muscles originally involved grow larger. On occasion the new bone may actually induce a pressure atrophy of the skin with the development of an ulcer which discharges white amorphous calcium. As the disease progresses there is interference with the function of the affected muscles and eventually the individual is confined to bed. When the rib muscles are affected breathing is carried on by the diaphragm alone but death eventually ensues from respiratory complications.

In a large number of the reported cases, some congenital abnormality of the fingers or toes has been present usually microdactyly.

HEREDITY

There is some evidence that hereditary transmission through the females to the males—as in haemophilia and certain of the muscular dystrophies—may play some part in myositis ossificans progressiva.

There is occasionally a rheumatic family history as well and Mau attaches some importance to the possibility of a subacute rheumatic myositis as a precursor of the osseous deposits.

The trauma of birth has been blamed but as Mau points out injury probably does little more than determine the site of primary change. Of more significance is the frequent history of antecedent infection—chicken pox scarlet fever cervical adenitis. The exact cause however is not known but it must act through the production of phosphatase in the cells of the proliferated mesodermal network that is the cells must assume the role and perform the work of osteoblasts. It may be that scattered throughout the mesodermal tissue of the limb there persist undifferentiated mesenchymal cells capable of forming fibrous tissue bone or cartilage. Mau suggests that in addition to this developmental factor there is a superadded but not understood disturbance of the calcium metabolism.

TREATMENT

No treatment is known to stay the course of the disease. Various drugs mineral and endocrine have been employed without effect and X-rays and heliotherapy are apparently useless.

LOCALIZED RAREFACTION IN BONE

In many localized diseases of bone rarefaction is a prominent feature. The process at least in those conditions which have been subjected to histological examination appears to present no essential

difference to bone resorption as it is found in the generalized rarefying diseases. It differs from the bone absorption of the remodelling process of bone only in its degree. For this reason it seems undesirable to refer to the bone changes, both local and general, as examples of bone decalcification—a process which should leave the osseous trabeculae soft, but essentially of a thickness similar to that which they possessed in their fully ossified stage. The very reverse, indeed, usually obtains, for histological examination shows marked attenuation of the trabecular struts from actual removal of tissue, not of lime alone. The misinterpretation has arisen partly through attempts to build up a pathology of bone from radiological appearances, and partly through an attempt to find a simple explanation to cover the radiological variations in bone structure.

Leriche and Policard Greig, Watson Jones and others have recently stressed the importance of the circulatory conditions in influencing bone structure. For bone to maintain its structure, there must be an equilibrium between the blood supply of the bone and its calcium content. Increase in the blood supply, i.e. hyperæmia, leads to solution of the calcium salts, diminution in the blood supply, ischæmia, leads to increased density—sclerosis—of bone, while complete deprivation of blood supply leads to necrosis. Taylor suggests that the decalcification is brought about through the phosphatase mechanism, the hyperæmia acting by washing away phosphatase as soon as it tends to form.

Hyperæmia, however, is a beneficent process that attends most tissue disturbances, and in no other situation does it so markedly disturb the tissue architecture. A more common effect of augmenting the blood supply of a tissue is to increase the tissue activity, and thus it might conceivably be expected to do in bone. It would be more rational to suppose that whatever activity was proceeding in bone would be stimulated by hyperæmia—if osteogenesis then bone formation would be increased, if osteolysis, then absorption, as opposed to decalcification would be increased.

POST TRAUMATIC OSTEODYSTROPHY AT JOINTS

(Painful post traumatic osteoporosis, Sudeck's atrophy)

Sudeck was the first observer to draw attention to a porotic affection of bone in the vicinity of a traumatised joint, but it is only of late years that the lesion has attracted much attention. Leriche, Fontaine and their co-workers in France, and Middleton and Bruce in this country have recently investigated the condition and it is their conclusions that are largely drawn upon in this account.

CLINICAL FEATURES

While the atrophy of bone is the striking objective feature, it is accompanied by an important and definite syndrome. The causal

trauma varies. Sometimes the condition succeeds a fracture but sprains and contusions also give rise to it. The trauma of arthrotomy as for example for meniscectomy may also be followed by osteodystrophy and it has been observed after burns and scalds.

The *locus of the disease* is most commonly the polyarticular areas of the skeleton such as the wrist and ankle. Nevertheless it has been observed at the shoulder, knee and elbow and apparently no part is immune.

The clinical evidences are characteristic. Thus the lesion is associated with (a) pain (b) stiffness of the affected joint or joints and (c) vasomotor disturbances.

The pain is ordinarily out of all proportion to the severity of the original trauma is not relieved by immobilization and only slightly by physiotherapeutic means. Forced movement and activity seem to aggravate it.

The stiffness is often so great that there is complete loss of function in the part. It is partly the result of protective muscle spasm.

The vasomotor phenomena vary. At first the affected part is warmer than its fellow, but soon becomes cold. Cyanosis is frequent and there is usually oedema. The skin is glossy and covered in the early stages by diffuse, sour smelling perspiration.

PATHOLOGY

The sequence of the pathological changes can best be followed by serial radiography.

In the first phase the affected bones show irregular areas of rarefaction with some diminution in their general density. This stippled osteoporosis is at the beginning confined to the spongyous largely because this is the site where the mineral content of the bone is most labile. Subsequently however progressive decalcification takes place and spreads to the cortex so that the whole bone acquires a glossy



Fig. 3—Late traumatic osteodystrophy affecting the carpal bones of a minor trauma.

appearance. These stages have been named by Middleton and Bruce the stages of stippled rarefaction and of cortico lamellar attenuation. For a long period the joint surfaces remain intact but ultimately

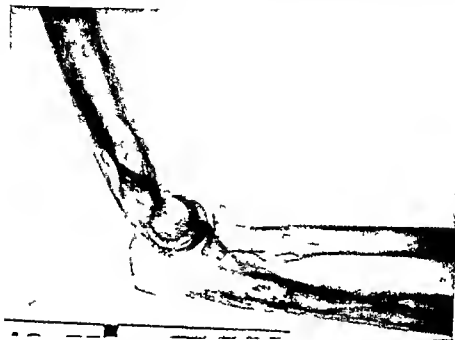


FIG. "4—Changes in Elbow Region in Same Case as Fig. "3

in the polyarticular areas the individual small bones become fused. In the latest stages when the acute atrophy has subsided calcium may be deposited in the capsule of the joint and lead to permanent ankylosis.

ETIOLOGY

Leriche attributed the condition to hyperæmia induced by a local autonomic axon reflex initiated by the injury. This is of course an invariable accompaniment of injury—indeed it is the factor that initiates healing. Why it becomes prolonged and why it is associated with so much pain is not clear. The other theory—that the condition results from the liberation of histamine from injured tissues—is also concerned with the explanation of the hyperæmia and not with the other features of the disease. Middleton and Bruce draw attention to the fact that after sympathetic denervation in these cases there is immediate relief of pain and recovery of movement while the osteoporosis is left unaffected. They suggest therefore that the injury sets up a persistent reflex consisting on the one hand of a painful sensation caused by afferent fibres running in the sympathetic system and, on the other hand of a reflex efferent impulse causing vasodilation and consequent osteoporosis. Probably a vicious circle is main-

maintains the local hyperemia keeping up the pain and the pain the hyperemia

PROGNOSIS

Mild cases may clear up with little or no residual disturbance of function but the recovery is protracted and this is the less usual result. More often there is permanent limitation of movement at the affected joint and in many cases the former bone density is never renewed. In some cases there is permanent ankylosis. Within these limits the outlook varies considerably with the site of the osteodystrophy. In the foot complete recovery may be expected in most cases. In a few there is left a rigid flat foot or a form of spastic flat foot. In the type following Colles's fracture permanent limitation of movement is the rule while the mild cases following sprains are often followed by complete recovery. At the knee and the shoulder some permanent stiffness is frequent.

TREATMENT

1 Simple Conservative Measures The usual physiotherapeutic measures are uncertain in their effects. Diathermy or radiant heat sometimes leads to improvement in mild cases. Massage and forced movement are difficult to apply because of the pain and are of no service in improving the condition. Complete rest in a suitable splint or plaster of Paris affords most relief. Deep X-ray therapy is said by some workers to be helpful.

2 Sympathetic Denervation Operations on the sympathetic system for the relief of post traumatic osteodystrophy were introduced by Leriche and his associates. They recommended a periaarterial sympathectomy on the main vessel of the affected limb. Middleton and Bruce found that this afforded only temporary relief and it would appear that operation on the sympathetic ganglia is more rational. A stellate ganglionectomy in the case of the upper limb and a lumbar ganglionectomy in the case of the lower limb is carried out. Since neither of these operations is easy and since in any case the milder cases show a tendency towards spontaneous and progressive anchorage sympathetic operations should be considered only in extreme cases.

The effect of sympathectomy is evidently to break the afferent path of the reflex and with the disappearance of pain and the return of function the hyperemia settles down.

3 The Use of Drugs The use of acetylcholine by ionization has given promising results. Acting as a para-sympathetic stimulant its effects are therefore similar to a temporary sympathetic denervation.

4 Orthopaedic Treatment As the acute phase subsides it is often necessary to augment the range of movement at the affected joint by judicious manipulation.

CHAPTER IV

AFFECTIONS OF BONES

OSTEOMYELITIS

Pyogenic infection of the cancellous tissue of bone is known as osteomyelitis

While localized inflammations of the periosteum periostitis—may occur organisms are much more likely to attack the marrow of the spongy interstices the medullary cavity and the Haversian systems. Where the process is acute bone destruction is the rule & chronic inflammation, on the other hand causes sclerosis.

The Bacteriology of Osteomyelitis The commonest infecting organism is the staphylococcus pyogenes aureus. Sometimes a staphylococcus albus may be found in which case the symptoms are less acute. The streptococcus occurs less frequently and is more apt to produce multiple lesions than the other organisms. When the bone is directly infected—from septic wounds a greater variety of organisms is likely to be present than in blood borne infections. In addition to those already mentioned B. Coli and the B. Aerogenes Capsulatus or the bacillus of malignant oedema may be found particularly in cases where the original injury was a compound fracture. The pneumococcus is occasionally isolated and is less virulent than the staphylococcus or the streptococcus. Typhoid osteomyelitis is not uncommon but the gonococcus is rarely found.

The Source of Infection The onset of osteomyelitis usually follows slight trauma. In some cases careful inquiry may elicit a history of some general blood infection preceding the injury since the vast majority are examples of a blood borne infection. The septicaemia however is of a mild type and often its presence is unnoticed. The organisms however, may have passed into the blood from the tonsils, the respiratory organs, the intestinal canal, genito-urinary tract or from excoriations, bruises, small wounds, or suppurations in the skin. Fraser believes that umbilical sepsis in early life may be the focus from which a blood infection arises and is responsible later for the development of osteomyelitis.

Certain fevers strongly predispose to the disease by preparing the soil for the growth of pyogenic bacteria. Smallpox, malaria, scarlet fever, measles, diphtheria and influenza for example, all lessen the vitality

resistance of bone marrow and favour the development of pyogenic organisms Typhoid fever is not uncommonly followed by chronic osteomyelitis due solely to the typhoid bacillus but if pyogenic infection is superadded acute osteomyelitis results. The resistance of marrow is also lessened by exhausting cases over exertion and inadequate food

When the organisms are introduced directly through a wound, as in a compound fracture the suppurative process invades the bone at the point where it is in contact with infected tissue, but ultimately the whole length and thickness may be attacked

The Localizing Influences It is universally agreed that a mild blood infection precedes the actual onset of the disease. What then are the influences which determine the site of the osteomyelitis? The vascular arrangements in the metaphysis and the influence of trauma are held to be important factors but the work of Hobo seems to indicate that lack of active phagocytosis in the metaphysis is of even greater import. Hobo injected fine particles of Chinese ink into the blood vessels of animals and found that they became uniformly distributed throughout the medulla. He also showed that the medulla was much richer in phagocytic elements than the metaphysis. Sections of both parts taken one to three hours after the injection of a bacterial emulsion into the blood stream showed the organisms evenly distributed throughout the medulla. Six hours later however the bacteria were found in the metaphysis only the medullary organisms having already been removed by phagocytosis.

There is no doubt that a preceding trauma has an important localizing influence. The usual type of injury is in the nature of an epiphyseal strain. The reason for this is that in the long bones the epiphyses are the only resilient or elastic tissues and consequently any strain applied to the limb is borne by them. The effect of the trauma is to cause hemorrhage and cell destruction in the region of the epiphyseal cartilage followed by diminished tissue resistance.

Children are continually receiving slight injuries of this kind and as they are to some extent painful there may be definite limitation of the function of the part from protective muscle spasm, in the lower limb for example there may be a distinct limp.

The Route of Infection The bone may become infected through the blood stream through the lymph stream by direct continuity from a neighbouring focus of infection or by direct inoculation from the body surface. In actual practice however blood stream infection is by far the commonest although with the increasing mechanization of our traffic and the greater frequency of compound fractures and accidental wounds direct infections are becoming more common.

The Incidence of the Disease Careful statistics show that osteomyelitis is a disappearing disease. In spite of this however, it appears that the condition comes in definite epidemics. It is believed by Williams and Timmins that these epidemics are coincident with a state of staphylococcal infection in the upper respiratory passages.

The lessened incidence is explained by the improvement in the general health and in the housing and sanitary arrangements of the people. The disease is commonest during the period of active bone growth. The maximum incidence is therefore between 3 and 10 years of age. The responsible factors are the greater liability to trauma and the frequency of mild blood infections at this time of life.

Boys are more liable to osteomyelitis than girls in a proportion of about 4 to 1. This also without doubt, is due to their greater liability to injury.

The bones of the lower extremity are more often affected and of these the tibia suffers most frequently. The upper end of the tibia is more commonly involved than the lower end. In the femur the lower end—the trigone—is the site of election. The greater amount of bone at these areas explains their greater liability to infection. The later the epiphysis joins the shaft the longer the metaphysis persists in a state of activity and the greater its liability to become infected.

Sequence of Events The successive stages in the development of acute osteomyelitis can now be summarized. In the prodromal period the child is the subject of a symptomless septicaemia, and bacteria are continually coursing throughout the vessels from some primary focus. They are carried to the bone by the nutrient artery and so enter the marrow cavity. Ultimately they reach the red marrow at the bone ends—i.e. at the metaphysis. Not only is this an area of enhanced vascularity but, in addition, the blood stream, because of the large size of the capillary loop is sluggish, the blood channels widen and the current slows down. The slowness of the stream is accentuated if the bone has previously been injured, or if the metaphysis is congested as a result of an inflammatory reaction. From the in-

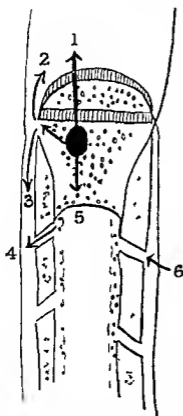


FIG. 73.—Osteomyelitis. The methods of spread. (After Platt.)

- 1 & 2 Into Joint
3 & 4 Into the sub-periosteal space
5 & 6 Into the medulla.

numerable falls which children sustain many minor injuries occur in the metaphysis—in the nature of small trabecular fractures, crushes and periosteal separations. Under such circumstances bacterial emboli are particularly prone to drift off to the sides of the blood channel and lodge in the walls.

While the initial focus in long bones is usually in the metaphysis

in the small cancellous bones the infection usually begins at the periphery of a centre of ossification. The older the child indeed the more likely is the infection to be distant from the epiphysis. Paschau believes that in early childhood the lesion is localized on both sides of the epiphyseal line—that it is in other words an epiphyseal as well as a metaphyseal lesion.

PATHOLOGY

As the bacteria multiply in this little embolus in inflammatory oedema is set up in the blood cavity so that in time the exits and the entrances are completely blocked and what is virtually an abscess results. The focus enlarges until it appears to the naked eye as a circular patch of oedematous and congested marrow. Microscopically in accumulation of inflammatory cells can be seen around the congested vessels.

Depending to some extent on the type and virulence of the organism the disease may take one of three courses

(a) When the patient displays a good resistance or the infection is a mild one the reaction in the surrounding tissue may be powerful enough to eradicate the organisms before suppuration occurs

(b) When conditions are slightly less favourable, i.e. when the organisms are more virulent or the phagocytic power less a chronic or Brodie's abscess may form

(c) The usual sequence of changes may occur the congestion being followed by suppuration and sequestration

When the disease follows either of the first two courses the acute illness gradually abates. Should a Brodie's abscess be formed the organisms sometimes retain their vitality for a considerable time and under certain circumstances may undergo a recrudescence of activity. In the centre of the cancellous tissue a cavity filled with thick pus develops and owing to the chronic nature of the disease the surrounding bone is sclerosed and condensed.

Usual Course of the Disease From the primary focus in the sub-arterial cancellous tissue of the metaphysis the infection is usually believed to spread with great rapidity to the medullary canal so that in a short time the



FIG. 70—Osteomyelitis of the femur the disease beginning in the lower metaphysis.

The distal shaft has formed an extensive sequestrum.

whole interior of the shaft may be filled with pus. The infection then spreads through the Haversian canals to the periosteum, which is eventually undermined and stripped from the bone by an inflammatory effusion constituting a sub periosteal abscess. The pus is thick, greenish, and oily, and may occupy the whole shaft from epiphysis to epiphysis, it may however, remain limited as a comparatively small focus in the metaphysis, the extent depending upon the intensity of the infection, and the patient's resistance. Occasionally it reaches the

epiphysis or even perforates the capsule and invades the adjacent joint. Starr, however disputes this commonly accepted conception of the pathology. He believes that infection of the medullary cavity is secondary not to the metaphysal but to the sub periosteal abscess and that it spreads from the original metaphysal focus along the line of the epiphysis to the periosteum. Here suppuration occurs and the pus extends rapidly under the periosteum stripping this structure from the bone surface. The medullary canal is most frequently invaded from the sub periosteal abscess through the Haversian canals. Starr has given convincing proof of his assertions by necropsy specimens by X ray photographs of cases seen at all stages, and by animal experiments.

At this stage of purulent infiltration, areas of bone are actually bathed in pus. The lamellae are poisoned by toxins deprived of their blood supply by thrombosis of vessels and rendered anemic by pressure. A large area of

cancellous tissue consequently undergoes necrosis, with the formation of sequestra. The compact surface bone is at first more resistant, but when the periosteum is raised its main source of blood supply—the



110 77—Osteomyelitis of the Trigone of the Femur

There is a complete involucrum and a large central sequestrum.

perosteal vessels—is cut off and its vitality impaired. The necrosis usually involves a considerable area, depending upon the degree of suppuration in the cancellous tissue and the extent of periosteum which is separated from the shaft. If the pus encircles the shaft, necrosis and sequestration of the entire circumference may ensue, forming the so called tubular sequestrum. Otherwise the sequestrum consists of a portion of the outer layer of the cortex and is more or less flake like in nature.

As the infection spreads the periosteum is perforated and the overlying soft tissues invaded. Should the synovial membrane of a neighbouring joint extend beyond the epiphyseal cartilage to the metaphysis infection may readily extend to the joint. In this way an osteomyelitis of the trigone of the femur may lead to suppuration within the knee joint.

If the progress of the disease is not arrested either by surgical intervention or death extensive necrosis of the shaft ensues. the medullary cavity is infiltrated and the sequestrum on its outside bathed with pus, the periosteum being extensively raised from the cortex. The periosteum may show several perforations through which pus is being exuded into the overlying soft tissues.

Ultimately, there is a reassertion of natural forces, the vascularity of the periosteum increases and a deposit of new subperiosteal bone appears which in time may completely surround the old dead shaft. This envelope of new bone is termed an involucrum and in the early stages is soft vascular and easily separated from the underlying bone. It is usually incomplete owing to the perforations which have taken place through the old periosteum which remain as holes or "closets" in the enveloping involucrum.

In the endosteal areas a similar reaction occurs and vascular granulation tissue forms on the surface of the still living bone between it and the sequestrum. In time it produces separation of the sequestrum or even absorption should the necrotic bone be small enough. The smaller cortical sequestra may be spontaneously discharged through the closets and thence to the surface by way of sinuses through the soft tissues. Large sequestra take a long time to be extruded and the sinuses persist for a very long time. This is one of the reasons for the long duration of convalescence from an attack of osteomyelitis. Another and perhaps commoner cause of persistent sinus is the presence in the interior of the shaft of a cavity the walls of which, being rigid cannot collapse and which is so deep that the soft tissues cannot fill it up.

When all the sequestra have been extruded, and when there are no cavities, complete regeneration may be accomplished, the dense compact bone of the shaft being remodelled and a cancellous interior again fashioned. If, however, the endosteum has been destroyed either by the disease or by too vigorous surgical interference, only an involucrum forms and the cortical sequestra composed of the entire thickness of the original cortex will lie in a bone cavity.

Tubular sequestra are seldom, if ever spontaneously discharged.

History of the Disease Before the actual onset of acute bone symptoms, there is often a period of general malaise. There may have been some local lesion such as tonsillitis, or a more general infection like measles or scarlet fever.

Careful inquiry will usually elicit a history of a slight injury in the nature of a blow or a fall.

The first local symptom is usually severe pain of sudden onset located in the neighbourhood of the joint, but occasionally the disease is ushered in by a rigor, followed by high fever and severe pain. In either case the abrupt commencement of the illness and the severity of the pain are the two notable features. Thereafter symptoms of severe toxæmia supervene, with in the more severe infections, delirium and coma which to some extent may obscure the local signs. If left alone, however, redness, swelling and œdema develop, indicating the formation of a sub periosteal abscess. Not infrequently, this stage is accompanied by a temporary remission of symptoms due to the relief of tension within the bone. It is, however, only temporary, as the sub periosteal area in turn becomes rapidly filled with pus.



FIG. 78 — Osteomyelitis of Upper End of Left Tibia Three months history

Treated by resection of upper part of diaphysis of tibia

If the resistance of the child is poor and the infection virulent, the stage of temporary improvement soon passes into what may be termed the focal phase, in which the local symptoms are entirely overshadowed by the general condition. There is delirium, coma, and hyperpyrexia, and the child eventually succumbs. If, however, the virulence of the organism is not marked and the resistance of the child is good, then there may be a further remission of symptoms when the periosteum is perforated and the soft tissues infiltrated with pus. The pus then infiltrates the fascial planes

following the lines of least resistance, until eventually it reaches the surface.

CLINICAL FEATURES

In the acute stage the child has all the appearances of a severe general illness. He is flushed and restless and complains of headache. The tongue is dry and furred and vomiting may occur. The pulse-rate is high—it may be as much as 120 or 140, there is marked pyrexia and a leucocytosis which may reach as high as 25 000.

The child is apprehensive in case the limb should be in any way interfered with and usually screams when it is being exposed. He may

object even to the bed clothes being touched, and sometimes even to his room being entered. With the development of the toxæmia however his apprehension diminishes, he becomes apathetic and finally comatose.

When the affected limb is inspected it will be found to be held in the position that exerts the minimum of pressure on the inflamed bone. The neighbouring joints are flexed in order to relax the overlying muscles.



FIG. 71.—Osteomyelitis of the femur.

Extensive necrosis of the upper end of the shaft produced as a result of separation of the epiphysis.

and accommodate the serous effusion which they constantly contain. In the early stages no swelling is apparent, but such quickly becomes evident when a subperiosteal effusion has occurred. Reddening of the skin is a late sign, and when present is localized, like the swelling to the affected metaphysis. Handling the limb elicits extreme pain, the maximum point of tenderness being situated over the original focus.

Kennon has carefully worked out in the various bones these points

of maximum tenderness in early cases of osteomyelitis. When for instance, the trigone of the femur is affected it is in the popliteal space in the case of the head of the tibia it is usually on the antero-medial aspect. When an abscess has formed under the periosteum it may be possible to detect fluctuation. If the neighbouring joint can be moved without increasing the pain arthritis can be excluded.

DIAGNOSIS

The early diagnosis of acute osteomyelitis is of great importance and should be possible from the signs and symptoms present. Severe pain in the neighbourhood of a joint with a point of extreme tenderness over a bone end is extremely significant in a growing child. If accompanied by high fever rapid pulse and a high leucocyte count the diagnosis is moderately certain. Occasionally however the general symptoms are so acute from the start that the local signs are obscured. In deeply seated areas such as the upper and lower ends of the femur swelling, redness and other local signs are very late in appearing and cannot therefore be used to assist the diagnosis. X rays also are of no assistance in the early stages. Salicylates should not be administered in the hope of eliminating acute rheumatism as valuable time may thereby be lost.

Differential Diagnosis

There are certain conditions which are liable to be confused with acute osteomyelitis.

✓ Acute Rheumatism. In acute rheumatism as in osteomyelitis there are both pain and swelling and also sharply localized points of tenderness but the onset is more gradual, the pain less acute and more definitely articular and the swelling confined more definitely to the joint. Further acute rheumatism affects usually more than one joint at the same time. Difficulty in discriminating between the two conditions is experienced in the main only with the milder types of osteomyelitis in which the onset is less dramatic and the progress relatively slow but even in these milder cases the toxæmia is always greater than in rheumatism and the leucocyte count higher.

✓ Erysipelas. Osteomyelitis may be mistaken for erysipelas because of the redness of the skin but in the latter there is less pain and general toxæmia. In erysipelas the definitely raised margin of the red area is significant.

✓ Cellulitis. Cellulitis in the region of the metaphysis should always suggest osteomyelitis but in pure cellulitis there is no intense pain and the general malaise is less. Both conditions require operation. In cellulitis the pus is found in the cellular tissues and the periosteum is not elevated by effusion as it is in osteomyelitis.

✓ Acute Pyogenic Arthritis. In acute arthritis sometimes leads to confusion but the manifestations in the joint are usually sufficient to differentiate the two conditions. In acute arthritis spasm of the

muscles is more marked, movements at the joint more limited, and effusion into the joint space of earlier onset than in osteomyelitis.

PROGNOSIS

Osteomyelitis is a dangerous disease and before the introduction of modern chemotherapeutic drugs the prognosis was grave. Kenny reported a mortality of 23 per cent in 1547 cases. With the discovery of the sulphonamides the mortality fell to about 10 per cent. Now that penicillin is available the outlook is entirely altered and the latest reports indicate a mortality of 2 per cent and also greatly lessened mortality subsequent to the infection. Altmeppen and Helmsworth describe a series of 31 cases treated with penicillin and McAdams one of 40 cases and in each there was only one death and no amputations. Deaths nowadays should only occur in late neglected cases or where the staphylococcus is penicillin resistant. The rapidity with which penicillin can bring an acute infection under control makes assessment of the results in acute osteomyelitis all the more difficult. Operation is frequently avoided and there may then be no proof that the condition was actually a bone infection and not simply an overlying soft tissue inflammation. Nevertheless the remarkable alteration in the prognosis of acute haematogenous osteomyelitis makes it justifiable to regard penicillin as the greatest advance that has yet been introduced in the treatment of this disease.

Certain factors have a decided influence on the prognosis.

(1) The Organism. Infection by *Staphylococcus aureus* is the most serious type.

(2) The Bone Infected. The nearer to the trunk the affected bone the more serious is the prognosis.

(3) The Age of the Patient. The younger the child the worse is the outlook.

TREATMENT

Though osteomyelitis can be rapidly progressive and quickly fatal and though its prompt and effective treatment is of the utmost importance is made clear by the statistics quoted above. Until modern chemotherapy per-



Fig. 80—Osteomyelitis of the Tibia

subject, after resection of the shaft had been done in early life and apparently growth had been interfered with. The shaft grew abnormally with the production of a severe adducted deformity of the foot. The condition was treated by osteotomy and bone-grafting.

mitted a different approach to treatment most experienced clinicians advised immediate and thorough drainage with wide opening of the cortex as soon as the diagnosis was made. Some surgeons thought it better to wait for from one to four days. This minority believed that the opening up of both the soft tissues and the bone—but especially the bone—in the virulent stage of the infection favours a wider spread of the infective process with a correspondingly greater local destruction and with more danger to life than the bone inflammation is only an incident in a general infection and that the shock and injury of untimely surgical intervention at the time when the patient is trying to elaborate his own immunity to the invading micro-organism may be definitely deleterious. It lays stress also on the importance of maintaining and conserving both the general resistance of the patient as a whole and the local resistance of the tissues and the absolute necessity of avoiding any procedure that may damage either the one or the other. It adopts the guiding principle of local treatment as carried out by the majority namely the establishment of early and effective drainage but insists that this must be secured without infecting healthy tissue and without further devascularizing bone that is already infected.

This belief that the osteomyelitis is only part of a general infection is now more generally held and as regards operative intervention the modern view is that it should be conservative and delayed for with prompt exhibition of penicillin in an early case no abscess may develop and consequently there may be no need for drainage. In a late case it may be necessary to incise the subcutaneous or sub periosteal abscess. Thus treatment of the local condition now becomes secondary to full treatment of the general condition.

Treatment of the General Condition.

As soon as the patient who is probably in a septicæmic state is got to bed full supportive measures must be instituted but nothing should take precedence over the prompt beginning of penicillin therapy. The drug will take 24–36 hours before beginning to show clinical signs of its effect during which time the patient may show no improvement or may even deteriorate. But after 24 hours the chances are that a sudden and quite striking improvement in his general condition will occur. It is therefore most important to begin penicillin at the earliest possible moment and to support the patient's general health until the drug and the body's resistance can master the infection.

The object of penicillin therapy always is to deliver a bactericidal or bacteriostatic amount of the drug to the infected area. In some surgical conditions this is best achieved by local therapy, but as a rule systemic therapy is the method of choice. In acute osteomyelitis the problem of getting the drug to the part is met by systemic therapy for in the acutely inflamed bone there is a good blood supply that will

carry the drug to all interstices of the bone. In addition, any concomitant septicæmia will be quickly controlled.

There is as yet no final agreement as to the correct dosage in acute osteomyelitis, nor of the best method of administration. Most authorities advise a dose of 120,000-200,000 units in the 24 hours, going on for a minimum of 14 days. The former is probably adequate for a young child, for a child over 10 years and for adults 200,000 units a day is advisable. Such dosage can be given either by 3 hourly intramuscular injections, each of 15,000 or 25,000 units dissolved in 1-2 c.c. of normal saline or distilled water, or by a continuous intramuscular drip infusion, dissolving the 24 hours' supply in 100 c.c. fluid. There is little to choose between these two methods of administration, either as regards efficacy or comfort to the patient. Continuous intravenous infusion is also effective, but usually has to be abandoned because of venous thrombosis at the site of injection. The commonest method is still 3 hourly intramuscular injections. The method of delaying absorption by dissolving the penicillin in a mixture of 1 per cent beeswax in pernut oil has not yet had extensive trial but it is possible that by such a method in future an 8 hourly injection may suffice.

How long to continue penicillin therapy is debatable, but certainly it should be continued until the temperature has been normal for at least 48 hours. McAdam suggests that 14 days is the minimum on the evidence that in his cases the time of clearance of organisms from the bone marrow as determined by marrow puncture was 14 days.

With penicillin therapy under way the patient's general condition should improve after 24 hours, but it may be necessary to treat anaemia by repeated small blood transfusions, preferably fresh and not stored blood. In the ordinary way it is not necessary to give sulphonamides in addition to penicillin, but if penicillin is not available or if the organism proves to be resistant, then a course of 36 gm. sulphathiazole should be started with 2 gm. and continued with 1 gm. 4 hourly. In such cases fluid should be administered by all routes including intravenous infusion of 6 per cent glucose in normal saline. Immunotransfusions will be found beneficial in some cases. Exsanguination replacement, suggested by Robertson of Toronto, in which a considerable quantity of toxic blood is withdrawn before blood transfusion may be tried.

Mercurochrome administered intravenously sometimes produces striking results, 20 to 25 c.c. of a 1 per cent solution may be given and repeated.

A stock vaccine may be used until an autogenous one is ready and is often helpful. An initial dose of 200 millions is given and this may be repeated on the third and fifth days. The vaccine can be given only when the temperature is normal, and its usefulness is limited. If septicæmia is severe and the temperature continuously high, a bacterial serum may be used. The usual initial dose is 10 c.c., but no

good effect is likely to accrue in severe cases unless much larger doses are given—e.g. up to 50 cc repeated daily.

Whatever the treatment carried out for the bone other parts of the limb should not be neglected and especially the joints above and below the affected area. The result of infection on the soft tissues and ligaments and their effect on the neighbouring joints must be considered. Deformity so easily occurs that it is not uncommon to find a patient recover from osteomyelitis with a good result as far as the bone is concerned but with a flexed and subluxated knee a foot in equinus or an arm fixed in adduction. In the early stages oedema etc. may render adequate splinting difficult but as soon as possible and certainly before any contractures have occurred, the limb should be placed in a position that renders such contractures impossible and such that if ankylosis occurs the limb is in the best possible position for function.

In the convalescent stage when there is often a toxic anaemia iron should be administered orally in the form of the saccharated carbonate or by intramuscular injections.

Treatment of the Local Condition

(1) *The Early Prodromal Stage* The efficacy of modern chemotherapeutic drugs justifies conservative and expectant treatment of the local condition in the early stages. The limb should be put at rest in a Thomas splint or a plaster bivalve so as to permit periodic inspection. If this treatment is begun within three days of commencement of the illness it is almost certain that operative intervention will not be necessary and indeed the results are worse when the knife is not withheld in such cases. If penicillin treatment is begun between the third and seventh day of the illness there is still a good chance that the process can be aborted. After the seventh day it is likely that operation will be necessary.

Prior to the days of chemotherapy and in some cases even now the aim of treatment at this stage was as Starr showed, to relieve tension beneath the periosteum and in the cancellous area of the infected bone.

In this operation an incision is made over the point of maximum tenderness avoiding the epiphysis. The periosteum is then incised and a series of holes drilled through the metaphysis passing obliquely towards the epiphysis. Starr believes that it is unwise to open the medullary cavity by chisel or drills in the early stage as such a proceeding may serve to introduce infection into a shaft which might otherwise escape. If pus is evacuated through the drill holes it is sufficient to introduce a drain which is retained as long as necessary. If no pus is found the periosteum is stripped off the bone for a short distance on either side of the incision to make certain that the incision has not been made in the wrong place.

Starr states that by these measures the symptoms are relieved and

that necrosis of an extent sufficient to produce actual sequestrum formation, is avoided

This simple operation is sufficient for those few cases that come for treatment at an early stage of the disease. In the majority however, the disease has usually advanced so far by the time treatment is undertaken that death of a portion of the bone is inevitable and that after the initial drainage further operations are required for the removal of sequestra

(2) *Treatment at the Later Stage* With penicillin cover it is justifiable to wait until the pus has ruptured spontaneously through the periosteum and formed an abscess in the soft tissues. This abscess can then be freely incised and drained and immobilization and penicillin therapy continued. Possibly major sequestra may form and require removal later but it has been shown that minor sequestra can be reabsorbed so that bony intervention at this stage is not indicated. The immobilization should not be in closed plaster because of the danger of reinfection from the pus soaked plaster. The discharge should be cleared away daily and the old fear that frequent changes of dressings in themselves will cause reinfection with streptococci and staphylococci need not be entertained if strict asepsis in dressing technique is observed and local penicillin as a cream or in solution employed. It is likely however that infection with penicillin resistant *Gram-negative* organisms will occur. *Pyocyanus proteus* and *B. coli* are obstinate invaders but can be treated with phenoxystol or proflavine.

The radiological changes in the course of and following penicillin therapy are interesting. Where treatment has been successful there is extensive decalcification which is progressive for 70 to 140 days. Sub periosteal bone formation is limited, small sequestra can be seen to become absorbed and finally recalcification is complete.

In the absence of penicillin therapy the medullary cavity should be more freely drained in order to relieve the medullary tension, arrest infection, reduce the risk of septicæmia and minimize sequestrum formation. The affected segment of bone is exposed through an incision passing down to, and through the periosteum in its whole length. If pus is not found on first opening the periosteum the membrane is elevated on either side of the incision until it is found and then it is evacuated. The operation however does not end with the drainage of the sub periosteal abscess, the medulla is exposed also. The cortical bone overlying the affected metaphysis is perforated with a burr or gouge, and from the opening a quantity of infected fluid usually escapes which may be thin and watery looking with fat droplets or even frank pus. The burr opening should then be enlarged just sufficiently to allow adequate drainage and in any case should not extend into healthy marrow since this would tend to spread the suppuration. It should be made to one or other side or to the front or the back of the bone for should a bone cavity result it will be more easily obliterated if it is not situated in the centre of the shaft. The under

lying marrow should not be interfered with, and least of all curetted, since any interference with it tends to disseminate infection and lead to further necrosis.

There is a wide choice of procedures in the after treatment of this operation. Drainage by long strips of dental rubber or by rubber tubing and packing with iodoform gauze have been advocated, for all practical purposes however, the choice lies between the following two methods.

(a) *The Carrell Dakin Method* Perforated capillary tubes are inserted into various parts of the gutter, connected with a Carrell Dakin tube and through them the wound is irrigated continuously. The results of treatment by this method are good.

(b) *The Winnet Orr Method* Orr believes that poor results are due to failure to combine the well known principles of asepsis, drainage, antiseptics and rest. His suggestions can be summarized as follows.

(1) Adequate drainage, the wound being left wide open to the depth of the affected area.

(2) A post operative dressing that will protect the wound, keep the part at rest and provide no opportunity for reinfection.

(3) Immobilization so that movement, pain and muscle spasm are entirely relieved and the parts retained in correct position for recovery with a minimum of deformity and instability.

A large incision is made over the infected area, and a gutter is chiselled out of the bone long enough and deep enough to expose the marrow cavity. No edges of bone should be left overhanging the diseased area and every care used to avoid any unnecessary damage to the medullary cavity. The wound is then dried, and wiped out, first with 10 per cent iodine and then with 95 per cent alcohol, it is then packed with gauze pads soaked in sterile vasoline and finally covered with a dry sterile pad and bandaged. The parts are next manipulated into a correct position—the arm is abducted, the foot is put up at a right angle, the hand is dorsiflexed, etc. Thereafter, a complete plaster case is applied to the affected part and retained without being split and without windows until dressing becomes necessary. This necessity is indicated by the odour of the limb, and till then the wound is not dressed unless there is a continuous rise of temperature or other sign of exacerbation. In the majority of Orr's cases dressings have been required at intervals of from ten days to four weeks.

The author has used this method of treatment both in osteomyelitis and in compound fractures, and has been greatly impressed with his results. The chief objection to it is that the odour of the pus retained under the plaster eventually becomes so intolerable, not only to the patient but also to the nursing staff, that segregation is necessary.

(c) *The Maggot Treatment of Baer* Baer, while working in France during the war in 1917, was struck by the fact already noted by Pare in 1537 that though the wounds of soldiers who had lain out in No

man's hand for long periods with severe compound fractures were alive with maggots there was found no fever or constitutional signs of infection and that when their wounds were cleaned there was found healthy pink granulation tissue. Some years later he actually used these natural scavengers in the treatment of chronic osteomyelitis with very satisfactory results. At first however the maggots were frequently found to be contaminated with such organisms as tetanus or gas gangrene but later this difficulty was overcome and Bier succeeded in breeding sterile maggots.

METHOD The wound is first washed with water and then opened up in such a way as to expose the deepest parts of it and any gross sequestra are removed. If much hæmorrhage occurs the wound is packed with sterile gauze for twenty-four hours after which the whole wound is filled up with the living maggots. The edges of the wound are protected by ahesive plaster which prevents any tickling by the maggots and the wound is then covered by a fine meshed wire net cage. The wound covered by the cage is exposed to the sunlight and the air as this has the effect of making the maggots bury themselves in the depths of the wound. At the end of five days the cage is removed and the maggots are washed out and the wound will be found to be clean, odourless and of markedly alkaline reaction. Fresh batches of maggots are inserted every five days and in about six to seven weeks in children the wound has healed the process taking rather longer in adults.

It is hardly likely that this method will ever be used in this country because its disadvantages are many and obvious and its advantages very problematical. Bier believes that the maggots by their scavenger action clear away the fragments of bone and tissue sloughs caused by



Fig. 21.—Osteomyelitis of the Tibia.
Superficial excision of the upper half of the bone has been carried out and the area is being healed.

operative trauma, and that the wounds become alkaline and in this way diminish the growth of pyogenic organisms. He thinks that there is less absorption and less toxic reaction, and that the wounds heal quickly.

Sub-periosteal Resection.

This operation may be performed at a late stage of osteomyelitis. It consists of total excision of the affected diaphysis, the plastic periosteum and the epiphyseal ends being carefully preserved. It may be carried out when the entire periosteum has been elevated from the underlying shaft, when the whole shaft from epiphysis to epiphysis is necrosed and forms a sequestrum, or when, as in the neglected case, the whole shaft is riddled with infection. There is no justification for adopting this method in the earlier stages of acute osteomyelitis before the behaviour of the periosteum can be gauged. The operator should have some guarantee that new bone is beginning to form under the periosteum, otherwise there may be complete or partial failure of regeneration of the shaft. A practical method of estimating this regenerative function is to pass a needle through the periosteum to the underlying new bone and so gauge its strength and its resistance. If the needle cannot be passed through the new bone, sub periosteal resection is contra indicated, as the bone would not collapse to fill the cavity. Diaphysectomy is usually reserved for one of the bones below the knee or elbow, where the other preserves the configuration and length of the limb during healing. Provided that the X ray film shows an involucrum $\frac{1}{2}$ inch thick, regeneration of the shaft usually occurs in patients under 17.

After resection it is important to prevent distortion of the limbs. In the case of a single bone such as the humerus, careful splinting and extension are required.

The Operation. A long incision is used, exposing the whole diaphysis. The periosteum is split and raised from the diaphysis right up to the epiphyseal disc by means of a curved periosteum elevator. The shaft of the bone is now divided about its middle by means of a Gigli saw, and the two halves of the diaphysis are wrenched away, the separation taking place at the epiphyseal disc. The periosteal envelope which is left behind is emptied of pus, and the cavity drained by dental rubber. The subsequent treatment is similar to that described for an early acute stage. A new shaft is rapidly formed, and since the epiphyseal cartilages have been left intact, any great degree of shortening is avoided. Where the necrosis is limited to one end of the bone a hemidiaphysectomy may be performed, in this case the bone is divided at its middle, but only the affected half is wrenched out.

Treatment of the Chronic Stage

The chronic stage is marked by the persistence of sinuses and by the repeated breaking down of wounds apparently healed.

Two factors are responsible for these

- 1 The presence of unabsorbed and retained sequestra
- 2 The presence of unobliterated cavities

The treatment of the chronic stage is directed to the eradication of both these conditions. The operations adopted at this stage of the disease unlike those appropriate to the early acute stages are not emergency measures designed to save life. They are methodical and sometimes tedious undertakings which if incomplete or lacking in thoroughness will have to be repeated at a later date.

Removal of Sequestra. It is essential that all necrotic cortical bone be removed otherwise a permanent sequestrum enclosed by an involucrum will result. It usually takes from two to three months before the sequestrum is isolated and separated from its bed and at this stage it can easily be recognized in a radiogram since it is more dense than the neighbouring bone and lies free in the cavity.

The limb is rendered bloodless by elevation and the application of a tourniquet. This facilitates operation and by preventing hemorrhage promotes convalescence. The area in which the sequestrum lies is then exposed by a suitable incision. The involucrum is identified and picked off the sequestrum by a blunt dissection. If the sequestration has extended beyond the limits of the original gutter the involucrum should be raised longitudinally at either end by a knife or osteotome, and the sequestrum gently extracted. Granulations should not be curetted. If it is still pliable enough the involucrum should be forced to collapse, so that any cavity left may be made as small as possible. The cavity is thereafter irrigated through Carrell Dickinson tubes, or gently packed with gauze. If the



FIG. 82.—Osteomyelitis of the femur with formation of a sequestrum.

sequestrectomy has been too long delayed and the involucrum has become hard and sclerosed it may be desirable to supplement the evacuation of the sequestra by an operation of the type discussed in the succeeding section

If the extent of the disease is great operation may leave an involucrum so weak and fragile that it will be unable to support the limb. In this event the limb should be carefully supported after the operation



FIG. 83.—Osteomyelitis of the Femur

- (a) The sequestrum is projected with its shadow to show its extent.
(b) A lateral view

by a plaster of Paris case or by some alternative method of splinting, and this should be continued until the newly formed bone is sufficiently strong to bear weight or withstand muscular traction. Radiograms by demonstrating the amount of new bone formation are the most efficient indicators of this stage.

Treatment of Bone Cavities The history of the case with bone cavities is depressing there is continuous or intermittent suppuration

and sinus formation with acute exacerbations, followed by re operation and further disappointment. The patients relate, more in sorrow than in anger, how they have been operated on or scraped ten, twenty, or it may be thirty times, and they illustrate their story by pathetic little collections of fragments of necrosed bone which have been collected as melancholy souvenirs of this prolonged discomfort. These cavities are usually the result of tubular sequestration and of the failure of new periosteal bone formation, occasionally they follow the operation of sub periosteal resection. The cavities often contain sequestra.

Before operation on a bone cavity, a clear picture of its location should be obtained by stereoscopic radiograms, both antero posterior and lateral, after the injection of lipiodol.

The Operation of Planifaction. This operation is a sculptural procedure, designed to ensure the complete removal of devitalized bone and so to alter the contour of the remaining bone that natural healing may take place. The operation is carefully carried out with the aid of a tourniquet and a wide exposure planned to ensure a good view of the bone. The periosteum is reflected from the affected portion of bone, but left undisturbed over the remainder. All sinuses are excised, and the cavities are made shallow so that the soft parts can collapse completely over the bone. Great care must be taken to avoid the removal of too much bone, as otherwise a pathological fracture may result. This is a serious complication, since the bone in this region is unhealthy and non union is prone to occur. At the completion of the operation the wound is packed loosely with dry gauze, and dressings applied.

Bone-filling Operation. Sometimes the cavities are too large to permit of the operation of planifaction, and in such cases removal of the bony walls of the cavity may leave too little bone to support the weight of the body. A filling operation is indicated under those circumstances.

THE OPERATION. A tourniquet is applied to the limb, and the cavity fully exposed. All diseased bone is carefully scraped out from the cavity, which is thereafter filled. The filling material may consist of an antiseptic substance, such as Mosetig-Moorhof's paste, or it may be a free graft of fat or even of bone. All of these, however, are inferior, in the author's opinion, to a pedicled flap of muscle and fascia. This pedicle-flap operation is simple, but must be carried out methodically and carefully, preferably in two stages, to prevent the absorption of the flap by sepsis. The first stage consists of a partial planifaction at one side, or part of one side of the cavity, so that, instead of a "well" with complete walls of bone all round, we have a well with a gutter running out of it at the same level as the deepest part of the "well." Loose pieces of bone are removed, as well as the fibrous walls of the well which are infiltrated with sepsis. The cavity is then cleaned out with strong formalin and treated afterwards by the Currell-Dakin irrigation. After an interval of three or four weeks the second part of the operation is

performed, which consists of the obliteration of the cavity by a muscle graft. A long incision is made, curving towards the neighbouring muscles, e.g. in the case of the head of the tibia, towards the calf. A large section of the gastrocnemius is freed at its lower, and left attached at its upper end. This flap is now turned up and the free end passed along the gutter into the well, and fixed in place with stitches round the top of the well. The skin is then sutured over it. At this point there may be some difficulty, particularly if the skin, as so often happens, is much scarred. There may even be too little skin as a result of the original incision. If the gap is not too great, a separate relief incision can be made posteriorly over the calf muscles, to allow the skin edges to come together over the bone cavity. The incision will granulate much more easily over the muscles than over the bone. If the gap is too big, it may be necessary to bring a tube graft of skin from the opposite leg, this should be anticipated and the skin graft made ready as a primary step in the treatment.

In the chronic stage of osteomyelitis penicillin has not proved so brilliantly successful as in the acute stage, mainly because of the difficulty of getting the drug to the part. One of the most important characteristics of the lesion is its poor blood supply. The sequestra and much of the scar tissue are avascular and therefore beyond the reach of any chemotherapeutic agent carried in the blood stream, and accordingly it is little use to treat a case of chronic osteomyelitis with penicillin unless it is combined with a radical operative attack on the wound. By such methods Buchman and Blair have reported good results in chronic osteomyelitis. They advise a radical excision of all devitalized soft tissue and bone saucerization of the cavity, and then a primary suture of the wound in layers. Systemic penicillin, 20,000 units 3 hourly is begun before operation and continued for 14 to 28 days. Other surgeons have reported similar results, and it seems that the best treatment for chronic osteomyelitis is to space the operation in the middle of a 28 day course of penicillin so that the wound is saturated with the drug and sterilized so far as possible beforehand, then a radical operation is carried out with primary closure if possible, followed by another 14 days of systemic penicillin.

Amputations for Osteomyelitis

Since osteomyelitis affects the growing ends of long bones it is to be expected that there may be some effect on growth. This has been investigated by Sergberg who examined 241 cases of long bone infection and found 5 per cent showed overgrowth, 31 per cent growth arrest, and in 64 per cent growth was undisturbed. Seventy eight per cent. of the cases of shortening had their initial disease in the upper femoral epiphysis. Infections in this region have the gravest significance, therefore, not only in respect of the immediate mortality but also in the ultimate prognosis.

Osteomyelitis especially when affecting the trigone of the femur, may lead to sinuses that are uncured, and, indeed, incurable. The only

radical cure for such cases the author believes is amputation. The loss of the limb is amply compensated for by the remarkable improvement in general health. An untoward development in very chronic cases that is not often thought of is the development of malignant disease. Benedict recently collected twelve personal observations of the formation of cancer in old cases of osteomyelitis. Most of the cases had had a discharging sinus for thirty years. The growth is always an epithelioma and the prognosis after amputation is said to be good.

PRIMARY TUMOURS OF BONE

The primary tumours of bone belong to the connective tissue group since they arise either from the periosteum the bone marrow or the cartilage. While they may originate either in the periosteum the compact bone or in the medullary cavity usually two or more of these structures are involved. Bone tumours are usually accompanied by secondary and sometimes marked alterations in the adjacent bone tissue. Thus osteoporosis and osteosclerosis are common while the new growths are apt to undergo calcification and ossification.

Classification of Bone Tumours The problem of the classification of bone tumours has been greatly simplified by the efforts of what has come to be known as the American Registry of Bone Sarcoma inaugurated by Codman. Their classification however does not include all bone tumours and moreover includes several conditions which should not be considered in this category. In the following classification the common non-malignant tumours of bone have been added, but the metastatic tumours and the inflammatory conditions adopted by the Bone Registry have been omitted.

Simple

| | |
|--------------------------|--------------------|
| Arising from osteoblasts | Osteonitis |
| " cartilage cells | Chondromata |
| " osteoclasts | Giant Cell Tumours |

Malignant Tumours

| | |
|-----------------------------|---------------------------------------|
| Arising from fibrous tissue | Fibro-sarcomata |
| osteoblasts | Osteogenic sarcomata |
| blood vessels | Angio-endothelioma |
| | Ewing's sarcoma (endothelial myeloma) |
| " marrow cells | Myelomata |

Exostosis, or Traumatic Osteoma Before proceeding to a consideration of individual bone tumours reference must be made to the condition variously known as *exostosis* or *traumatic osteoma*.

The original teaching of Illand Sutton was that the term should be

restricted to those bony outgrowths which resulted from irritation inflammation or trauma in tendons at their attachment to bone. The traumatic exostosis was supposed to arise through splitting or tearing of the periosteum with subsequent liberation of osteoblasts into the overlying tissues where they lead to a deposit of new bone. The modern bone pathologist views them rather as an expression of hyperæmic decalcification. It is supposed that some injury leads to the formation of a sub periosteal hæmorrhage the periosteum being detached by muscular traction. If the periosteum remains intact the hæmatoma may become absorbed but if the periosteal re apposition and the absorption of the blood clot are prevented by ill advised movements or massage the clot becomes surrounded by proliferated fibroblasts which are later converted into scar tissue. In this scar tissue relatively avascular and functionless calcium crystals are laid down and, serving as an irritant they act by revascularizing the area. This hyperæmia in turn produces a local excess of calcium and the fibroblastic tissue redifferentiates and acquires bone forming characteristics.

The resulting exostosis in this case is smooth and firmly adherent to the bone.

If the periosteum ruptures the blood escapes into and percolates along the fibrous tissue planes and septa and the subsequent deposit of new bone is therefore rough of irregular shape and elongated in the long axis of the muscle amongst whose fibres it is being deposited.

Occasionally a similar effect may follow tears of tendon and muscle fibres without actual damage to the periosteum. In such cases the new bone laid down has apparently no continuity with the adjacent bone.

Traumatic osteomata are most frequently observed in relation to the femur beneath the quadriceps or in relation to the adductor magnus (the so called rider's bone). The condition is also not infrequent at the elbow the exostosis forming in the intermuscular planes of the brachialis anticus following dislocation.

The inflammatory and irritative types are perhaps most commonly observed on the plantar aspect of the os calcis following plantar fascitis. In this case the periosteum is raised not by a hæmatoma but by a mildly virulent inflammatory effusion but the subsequent stages in the development of the calcanean osteoma or spur are similar to the traumatic type described above.

THE SIMPLE TUMOURS

1 Osteoma (Biotrophic Osteoma)

The biotrophic osteoma is the commonest of the true simple tumours of bone. It may be composed of compact tissue—a compact osteoma—or of a mixture of cancellous and compact tissue—the so called cancellous osteoma.

(a) **Compact Osteoma** This tumour is composed of tissue as dense and hard as ivory and is frequently termed the ivory exostosis. It is usually small and sessile and occurs most commonly on the skull especially on the frontal and parietal bones. There is a deposit of dense sub periosteal bone due to the eruption of osteoblasts at a single point



FIG. 84—Exostosis of Tibia growing into the fibula



FIG. 85—Exostosis of the lower End of Femur

as a result of some obscure irritation. It is usually single and grows slowly; its surface is smooth but may be slightly nodular. As it grows it tends to become more conical. When these tumours grow from the inner table of the cranial bones they may cause pressure on the brain. They are also found in the frontal sinus, in the roof of the orbit, and in the walls of the external auditory meatus. They are of little interest to the orthopedic surgeon.

(b) **Cancellous Osteoma** This tumour, also called a spongy

exostosis, or an ossifying chondroma, arises from the epiphyseal cartilage. When fully formed, it consists of a shell of compact bone enclosing cancellous tissue, with a cap or tip of cartilage. It is usually pedunculated, with a bulbous extremity. It occurs during adolescence, never after the epiphysis has united, and boys are more frequently affected than girls. The condition may be familial.

In structure the tumours bear a close resemblance to those occurring in metaphyseal aclasis, already described. The epiphyseal cartilage may grow beyond its normal limits at one point and the extension becomes segregated to form the tumour. The shaft of the bone grows more rapidly than the osteoma so that the long axis of the tumour assumes more of an acute angle with the shaft of the bone. When the epiphysis becomes united, the cartilage over the tip of the osteoma disappears, although for some time hyaline cartilage may cover over its bulbous tip. The pedicle of the osteoma grows as long as the shaft of the bone grows, but ceases when the growth of the shaft stops. When fully developed, the marrow of the shaft is continuous with that of the cancellous tissue of the osteoma.

These tumours are commonest at the extremities of the bones especially at the ends where the epiphyses are the last to join the shaft. The lower end of the femur, the upper end of the tibia and the upper end of the humerus are consequently the commonest sites.

The summit of these growths is often covered by an adventitious bursa, and not uncommonly they interfere with the free action of muscles or tendons or with the movement of joints. Osteomata are frequently found growing from the epiphyses of flat bones such as the scapula and the innominate.

2 Chondromata

A chondroma is a benign tumour arising from the cartilaginous elements of the developing bone. It grows slowly, and is generally lobulated and encapsulated by fibrous tissue. Calcification frequently occurs in the fibrous septa dividing the lobules, while the intercellular matrix may undergo mucoid degeneration, particularly in the large chondromata which grow from the innominate bone. Ossification, however, is uncommon.

Microscopically there is a hyaline matrix containing cartilage cells, encapsulation and lobulation are present and calcification and mucoid degeneration are common.

The capsule is formed by vascular connective tissue which sends septa into the tumour substance, thus dividing it into lobules. Chondromata may be multiple particularly in the short long bones of the hand and foot, or single, usually affecting the long bones. Further, they may occur mainly within the confines of the bone—"enchondroma"—or without the bone—"exchondroma".

(a) Multiple Enchondromata Multiple enchondromata occur

in childhood and affect the short long bones of the hand and foot so that the part may be distorted, and appear to be of excessive size. They arise in the centre of the shaft as a collection of cartilage cells which in process of growth gradually expand the surrounding cortex.

It has been suggested that these tumours arise as a result of deficiency in the nutrient vessel and it seems reasonable to believe that an imperfection in the early vascularization of the cartilaginous framework has left within the centre of the shaft isolated islands of cartilage which have later assumed proliferative activity.

It is usually thought that multiple enchondromata are not true tumours though indistinguishable from solitary chondromata occurring in adults with neoplastic characters. The alternative view that they are the expression of a growth disturbance—is supported by their frequent occurrence in association with metaphyseal dysplasia (95).

The tumours are simple they are deforming and ugly but otherwise harmless. If left alone they may disappear when growth in length ceases.

TREATMENT

Platt believes that operative treatment is indicated when the tumours are rapidly growing and have become unsightly or a source of inconvenience. Complete excision with curettage and cauterization of the tumour bed is essential. Should this procedure lead to the collapse of the fragile bony shell of the affected bone he recommends that the shell be packed with autogenous bone chips and the part carefully splinted. The tumours should be dealt with at successive operations.

(b) The Solitary Cystic Enchondroma—In the short long bones of the hand and foot there is occasionally found a solitary enchondroma



Fig. 86.—Osteoid in a of the foot.
This was a chondroma.

They usually occur in the metaphysial region of a proximal phalanx or metacarpal and seem to be especially common in the little finger. The tumour arises insidiously, and remains symptomless for long and attention is often directed to it through trauma, or the occurrence of a pathological fracture.

The tumour is at first composed of cartilage cells, but has a decided

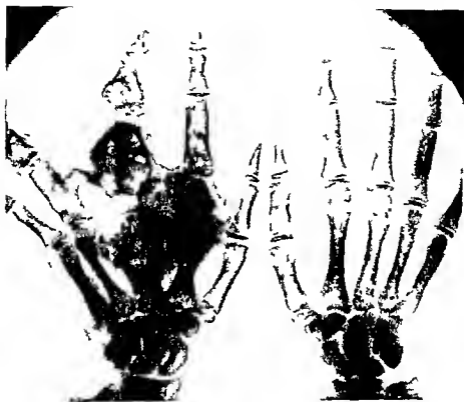


FIG. 87.—Multiple Chondromata of the Hands

tendency to undergo myxomatous degeneration. In the process of growth it may greatly expand the cortex of the affected bone. Usually benign malignant change has supervened on numerous occasions.

TREATMENT

Platt points out that during the stage of active cortical expansion, or after the occurrence of pathological fracture, the cyst should be curetted and its cavity cauterized, bone grafts being inserted where the integrity of the parent bone has been threatened. In this way rapid and permanent healing results. When the cyst wall is thick, and is not giving rise to symptoms it should be left alone.

Other Cysts of the Short Bones of the Hands and Feet

Reference may here be made to cysts of the hand and foot of other than chondromatous origin.

These also arise insidiously and may be present for long before attention is focussed on them through the complication of a pathological fracture.

Platt in a valuable paper analyses the pathological and clinical aspects of this important condition. In certain of his cases the appearance of the cyst at operation bore a close resemblance to the morbid



FIG. 88—(a) Chondroma of 4th Metacarpal

(b) After excision and implantation of bone graft.

appearance in *osteitis fibrosa cystica*—the cyst was imperfectly filled and sometimes even empty and the lining was composed of thick fibrous tissue which peeled off easily. The characteristics serve at operation to distinguish between this variety of bone cyst and the cystic enchondroma.

The histological appearances are those of *osteitis fibrosa* with absorption of the trabeculae of the affected bone and fibrous tissue replacement. Giant cells may or may not be present. According to Bloodgood, Gecklacher and Copland these cysts should be further subdivided into

(1) A group corresponding histologically to osteitis fibrosa *

(2) A group in which amongst the fibrous stroma of the tumour there are a few scattered giant cells smaller than those of the typical giant-celled tumour—the giant-cell variant of the bone cyst

(3) A group in which large numbers of typical giant cells are scattered throughout the stroma of spindle celled connective tissue which however predominates—the spindle celled variant of the giant cell cyst

In this way these observers seek to draw attention to the frequent relationship between osteitis fibrosa and giant-celled tumour though the latter in its classical form is not found in the short bones of the hand and foot

CLINICAL FEATURES

From the clinical aspect symptoms arise when trauma results in a fracture or when the enlarging cyst produces pain, and this directs attention to a gradually increasing swelling. The hand is more often affected than the foot

✓ RADIOLOGICAL SIGNS

At first the cyst is located at the metaphysal area of the affected bone but gradually becomes displaced down the shaft as the bone grows. The cortex is usually expanded and the trabeculae are largely destroyed though traces of them may be seen as fine streaks running through the otherwise structureless area. There is no sub periosteal new bone reaction

The radiological signs are similar to those of the cystic enchondroma and the two lesions cannot therefore be distinguished on X ray examination but only at operation—the chondroma is filled with bluish white translucent material the cyst with crumbly brown tissue—and on histological examination

TREATMENT

The treatment is similar to that for cystic enchondroma

(c) The Single Ecchondroma. This variety of chondroma is distinguished by the fact that it projects from the surface of the affected bone though it may also penetrate for some distance into the interior

The favourite sites are (1) the ends of the major long bones—the femur tibia (especially in the region of the knee) and the humerus and (2) certain flat bones—the innominate and the scapula

It is generally supposed that the tumour arises from the epiphyseal cartilage though Virchow has suggested that it may arise through neoplastic proliferation in islands of unossified cartilage in the shaft of the bone. These islands he attributes to rickets since they are mainly found in young rachitic adults

PATHOLOGY

The tumour possesses a well encapsulated lobulated mass of semi translucent tissue in intimate association with the parent bone. The

main bulk of the tumour is above the surface of the bone but frequently it has extended to the adjacent part of the metaphysis

THE HISTOLOGICAL APPEARANCES

The bulk of the tumour is composed of cartilage cells in varying degrees of perfection from the very embryonic to relatively well formed adult cartilage. Small areas of ossification are often present and occasionally myxomatous or sarcomatous degeneration.

The tumour may attain a very large size and invade the adjacent bone and undermine its structure without showing the histological criteria of malignancy.

CLINICAL FEATURES

The tumour arises in adolescence but may remain small and unnoticed for many years till it gives rise to inconvenience by its size or by its position causes pressure on nerves or interferes with movement of the adjacent joint. Occasionally a pathological fracture is the first evidence. Malignant transformation occurs as a rule after the age of 30 and is heralded by a rapid increase in the size of the tumour and by the presence of pain.

RADIOLOGICAL SIGNS

The X ray picture is generally held to be characteristic—a dense shadow with a feathery outline composed of calcified spicules or splastics (Platt). In the absence of calcified or ossified areas in the tumour the tumour is virtually invisible though it may be suspected from the greater density of the soft tissues in relation to the bone.

TREATMENT

The well formed fibrous capsule enables the tumour in most cases to be cleanly excised and even in the case of very large tumours this may be accomplished with surprising ease. When sarcomatous change has supervened amputation should be performed and a course of deep X ray therapy provided.

3 Benign Giant celled Tumour of Bone

Although it is now known that giant cells are a common histological feature of many of the morbid states of bone there is good reason for regarding the giant celled tumour as a distinct clinical entity with an equally definite method of treatment.

Characteristically the benign giant-celled tumour is pointed out by Bloodgood and his associates and by Platt as an epiphyseal lesion in contrast to the osteogenic sarcoma which occurs in the metaphysis. It begins in the cancellous tissue, and leads to progressive destruction of the bone trabeculae. Such local destruction may be uniform or the tumour may grow eccentrically and reach the surface of the bone on one or other aspect. As it progresses the epiphyseal cartilage may be destroyed and sometimes the tumour may penetrate the articular

cartilage and gain entrance to the related joint, though this is exceptional

Although locally destructive as regards the parent bone, the giant celled tumour does not infiltrate save to a limited extent and practically never gives rise to metastases. The tumour is therefore regarded as benign and when local recurrence follows operative intervention it is usually supposed that the treatment has not been radical ✓



FIG. 89 — Benign Giant celled Tumour of Clavicle

PATHOLOGY

The usual variety of giant-celled tumour is composed of reddish brown soft tissue, resembling vascular granulation tissue, amongst which there may be cystic areas, refractile fatty areas, and bone debris. Situated primarily in the medulla the tumour leads to progressive destruction of the bone trabeculae, and gradual attenuation and expansion of the cortex. The intramedullary spread of the tumour is limited to the cancellous tissue at the bone end, and it does not possess the same tendency as the osteogenic sarcoma to spread along the medulla. New sub periosteal bone is never found. The expansion of the cortex to a mere film gives rise to the characteristic egg shell cracking and the weakening of the bone may precipitate a pathological fracture.

HISTOLOGY

The histology of the tumour is a main characteristic. The main bulk of the tissue is composed of spindle shaped fibroblastic cells amongst which there are scattered numbers of giant cells. These possess a homogeneous cytoplasm and contain from ten to thirty nuclei which are usually centrally disposed. Occasional foam cells containing lipid material are found and the blood vessels are well formed.

The Origin of the Benign Giant-celled Tumour The origin of the benign giant celled tumour is one of the puzzles of bone pathology. Strikingly similar histological features are found in the giant-cell collections—so called osteoclastomata—of osteitis fibrosa cystica and on this account many including Geschlechter and Copeland do not regard this lesion as a bone tumour, but as a reaction of osseous tissue to a



FIG. 30.—Benign Giant-celled Tumour of Bone

noxious stimulus the giant cells being of the foreign body type and present for phagocytic purposes.

The modern belief is that the lesion is truly neoplastic and that the giant cells are derived from the osteoclasts.

CLINICAL FEATURES

The tumour usually affects persons between the ages of 20 and 40. The majority occur in the lower limb and especially in the vicinity of the knee, though any long bone may be affected and occasionally the jaw, the flat bones of the skull the patella vertebrae, and tarsus.

The first symptom is generally pain, and at this time the affected part of the bone is tender. This early appearance of pain and tenderness is of great importance and may suggest a possible inflammatory process. The pain gradually increases in severity and ultimately a swelling appears. This may be asymmetrical when the tumour grows

eccentrically when the tumour is central the affected bone presents a bulbous shaped enlargement towards its extremity

Occasionally, pathological fracture is the earliest feature and rarely the tumour is not seen till it has infiltrated the soft parts, the adjacent joint or even fungated through the skin



FIG. 11.—Benign Giant Cell Tumour of the Tibia.

X ray Appearance The radiological appearance of a giant celled tumour is characteristic. The end of the bone is enlarged and occupied by a clear multi cystic swelling. Osseous trabeculation may be seen at the periphery of the cyst. The cortex is thin and sharply limits the tumour from the surrounding soft tissue. There is a sharp line of demarcation between the tumour and the unaffected shaft in contrast to the appearance of sarcomata and the bone cysts. When the whole shell is destroyed, however it may be difficult to differentiate it from an osteolytic osteogenic sarcoma. The appearance of the

adjoining periosteum and cortex serves to distinguish it from osteogenic sarcoma, while in the latter some remnants of bone structure will usually be seen in the substance of the tumour, in the giant celled tumour the bone structure is entirely replaced. The osteogenic sarcoma, in addition does not reach the articular cartilage, where the giant celled tumour is in direct contact with it.



FIG. 12.—Benign Giant celled Tumour of the Base of the Neck of the Humerus.

Note the lobular shape with expansions of the bone, the sculptable trabeculation, and the wall of bone protecting the medullary cavity.

White Myeloma Occasionally a rare tumour showing all the microscopical appearances of a giant celled tumour, but white in colour, is found at the lower end of the radius. The tumour is a true benign giant celled tumour, the difference in colour being due to the absence of vascular tissue.

TREATMENT

While many of these tumours can be dealt with successfully by

curettage, this form of treatment is not without danger, as *recurrences* are frequently reported. Such recurrences may exhibit increased growth capacity, and even become malignant. Also, the large cavity left may fail to heal and a difficult surgical problem is then presented, which may be solved only by amputation. Infection of the cavity may also be a sequel.

Deep X ray therapy appears to give reasonable hope of permanent cure, although in three to four weeks after the treatment, the appearance is that of a rapidly growing malignant tumour. This acute stage however, quickly subsides and a dense fibrosis with rapid regression of the tumour results.

THE MALIGNANT TUMOURS OF BONE

1 Periosteal Fibro-Sarcoma

This tumour originates in the fibrous layer of the periosteum, and is therefore entirely extra-cortical, it neither invades nor infiltrates the bone and since specific bone forming tissue does not enter into its primary composition should not be regarded as a true bone tumour. In structure it is similar to the fibro sarcoma which arises from fascia in other situations. The tumour remains encapsulated for a long time and as it grows it pushes aside the soft tissues, but rarely infiltrates them.

Secondary changes eventually appear in the underlying bone, but they result from the pressure and the contact of the tumour. Saucer shaped erosions may occur where the cortex is in contact with the tumour, and areas of new periosteal bone formation at the periphery.

The tumour is firm fibrous white and glistening with easily distinguishable fasciculi. Occasionally it is cellular, soft and crumbly, containing cysts. The degree of vascularity varies with the cellularity of the tumour. The tumour may appear to be encapsulated, but the capsule merely consists of the condensed surrounding tissues. It remains localized for a considerable time but ultimately, as the vascularity and cellularity increase, it becomes more malignant. At this stage secondary metastases usually occur in the lungs.

Histologically the tumour is a fibro sarcoma of the spindle cell type, the cells resembling fusiform fibroblasts.

CLINICAL COURSE

This type of tumour is rare and very few cases have been recorded. Kolodny believes that owing to the difficulty in distinguishing it histologically from fascial sarcoma, and the fact that its relationship to the periosteum may remain unrecognized, it may be commoner than is usually thought. The onset, course, and physical findings are exactly similar to those of a fascial sarcoma. They have a broad attachment to the periosteum but in spite of this these tumours may appear freely

movable over the underlying bone. There is no particular tenderness, one has been observed even in a new born child

DIAGNOSIS

The X ray film shows a faintly outlined soft tissue shadow the cortex opposite which often shows a shallow saucer shaped depression. Beyond this bone changes are conspicuous by their absence



FIG. 33—Periosteal fibro sarcoma of the Lower End of the Femur

The iliac spines are seen in a lateral aspect of the femur rendering the size of the bone greater

TREATMENT

Radical removal of the tumour is the operation of choice. The prognosis is especially favourable when the tumour is encapsulated. If the operation is incomplete it may be followed by local recurrence and general metastasis. The operation should be supplemented by a prolonged course of deep X ray therapy

2 Osteogenic Sarcoma

Osteogenic sarcoma is the term employed to describe the commonest tumour of bone and it includes a number of tumours formerly regarded as distinct entities. The term is in some ways bad for it is often taken to mean that the tumour forms bone whereas it was intended to indicate a tumour growing from the cells which form bone (osteoblasts) or their immediate ancestors.

The osteogenic sarcoma is relatively rare the incidence in Great Britain being 1 per 75 000 of the population. It may occur at any age period but has a decided predilection for the second decade. In older individuals it is an occasional sequel to Paget's disease, and rarely to a neglected giant-celled tumour.

The tumour arises in the metaphysis where normally the growth is more active. The large majority are found in the lower limb especially the lower metaphysis of the femur and the upper end of the tibia. Less usual sites are the upper end of the humerus the radius ulna ilium and the scapula. For some reason the short long bones appear to be immune.

PATHOLOGY

Bone sarcoma is occasionally classified into several groups. Thus when it commences beneath the periosteum it has been called—badly—the periosteal type and when commencing deep to the cortex it has been called central sarcoma. There is nothing to be gained by this artificial distinction. In the first place the so-called central tumour is so rare that if a tumour is found in this situation expanding the bone equally on all aspects it is presumptive evidence against a diagnosis of sarcoma. Further it is impossible by the time the tumour gives rise to clinical evidence to assign its origin to any particular location in the bone.

From its initial situation the tumour extends in two directions—(i) towards the medulla and so up the shaft and (ii) to the sub periosteal area. In the medulla the bone trabeculae are decalcified and destroyed and the tumour appears as an irregular mass permeating the medullary cavity. At first the periosteum offers an impenetrable barrier and is only raised off the bone. Beneath the membrane the tumour may extend widely ensheathing the bone and producing a fusiform swelling. The periosteal separation stops short at the attachment of the periosteum to the epiphyseal cartilage. Similarly the intramedullary part of the tumour does not transgress the cartilage of the epiphysis—a useful point in distinguishing between it and a benign giant-celled tumour.

The tumour varies greatly in appearance. It may be soft fleshy and vascular with areas of haemorrhage and necrosis or it may be greyish white and solid when it contains cartilage or bone. In the first type there is little or no new bone formation the tumour is

largely a destructive one and is often known as an osteolytic tumour. In such cases its vascularity may be so great that the tumour appears to pulsate—the so called 'telaqueatic sarcoma' or 'malignant bone aneurysm'. When much new bone is present and the tumour is hard it is referred to as the sclerosing type or ossifying sarcoma. The new bone may be arranged as scattered islands throughout the tumour which impart a gritty sensation on cutting and that found beneath the periosteum is usually arranged at right angles to the cortex as a series of radiating spicules. To this arrangement is attributable the sun ray appearance so characteristic in the radiographs. This peculiar arrangement is due to the vessels which pass perpendicularly from the periosteum to the cortex and along which the bone is laid down. On the diaphysal side of the tumour the periosteum is often stripped for a short distance and here there may be deposited small parts of new bone arranged parallel to the shaft. This area is triangular in shape and is usually referred to as Codman's reactive triangle.

Outlet of the Tumour If the sarcoma grows rapidly and the perosteal reaction is weak pathological fractures may occur. This at once provides an outlet for the expanded tumour and leads to its ultimate phase of infiltration of the soft tissues. More frequently this phase is reached by perforation of the periosteal capsule. The tumour then changes its line of growth and infiltrates the surrounding tissues in a centrifugal direction. It then possesses a pedicle passing through the perforation and the fin-like structure is lost the tissue having no evident arrangement. The muscles become stretched and atrophied until the tumour is eventually covered with glossy skin. Ulceration of the skin is unknown—it is simply stretched and atrophied. Cartilage is even more resistant to osteogenic sarcoma than skin owing probably to its lack of blood vessels.

It is easy to see that in exploratory incision or an attempt to local excision of an osteogenic sarcoma may radically change the entire course of the disease. The perforation of the periosteal capsule which will occur in the natural course of events is precipitated by the surgeon.



FIG. 31.—Osteogenic Sarcoma of Lower End of Femur.
The distal end is visible.

Consistency. The consistency of the tumour is influenced chiefly by the degree of differentiation of its constituent elements. There are all the transitional stages from the first attempts at organization of blood clots, through the stage of fibrosis and cartilage formation, up to consolidated bony callus. There is some evidence which tends to show that fibrous tissue, myxomatous tissue and cartilage are definite stages through which osseous tissue may have to pass during its development and all these may be met with in osteogenic sarcomata. In some the differentiation of the tumour elements has stopped at the



FIG. 93.—Osteogenic Sarcoma of the Femur with Pathological Fracture

formation of fibroblasts in others it has been side tracked to myxomatous tissue in others the cells go no farther than cartilage, while in some osseous tissue is formed. In the majority of cases usually two or more of these various tissues may be simultaneously observed.

HISTOLOGY

It is generally accepted that the osteogenic sarcoma arises from the osteoblast or its predecessor, which is a mesenchymal cell. The histological picture accordingly varies considerably, and there is no uniform type. Variety is also shown in the intercellular substance which may

be scanty or plentiful. The absorption of the original bony framework and the deposition of new bone by the tumour also complicate the picture.

The most frequent cell is a small spindle shaped fibroblastic cell with hyperchromatic nuclei and showing rapid mitotic division. In many tumours the cells are large and polyhedral in shape and occasionally typical small round cells are found. Usually all types of cell occur in different segments of the same tumour and the differing varieties are usually taken to represent different degrees of differentiation of the primitive mesoblastic cell.

The cells may be arranged in a conglomerate mass or in parallel or interwoven fasciculi. Rarely they may assume an alveolar arrangement or be grouped in palisade formation.

The intercellular substance may be scanty or when present may be myxomatous, cartilaginous, osteoid or osseous in type again depending on the degree of differentiation of the tumour.

In areas where bone is being rapidly destroyed giant cells of the osteoclast type may be found in relation to the disappearing trabeculae. These are rare in the usual type of tumour but bulk largely in the osteolytic type.



Fig. 10—Osteogenic Sarcoma of the Head of the Femur.

The tumour cells destroy all the bone (a) of the bone.

CLINICAL COURSE

Osteogenic sarcoma is principally a disease of the young and is commonest in the second decade of life. It usually affects one bone only but may be superimposed on metaphyseal achasia. There are two outstanding features in the clinical history. Pain especially at night is usually the first symptom and precedes the tumour by days or weeks.

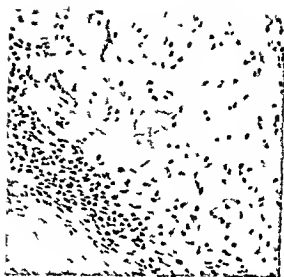


FIG. 97.—Osteogenic Sarcoma

or months. It is due to the severe sensitiveness of the periosteum and such pain in the long bone of a young adult should arouse suspicion of sarcoma. Less commonly there is only a tired feeling and a slight limp. The pain is intermittent.

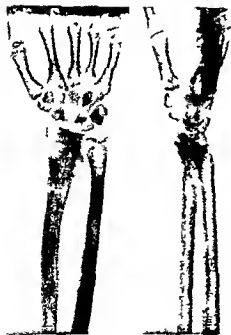


FIG. 98.—Osteogenic Sarcoma of the lower end of the radius

This is a rare site for the disease

The second important feature in the clinical history is trauma. History of trauma however is often unreliable and suggested for purely mercenary reasons; moreover it is not difficult to connect any part of the body with the memory of some previous injury. Codman believes that trauma is the exciting cause of all osteogenic sarcomata, while maintaining that the particular trauma to which the onset is attributed by the patient is seldom the causal one. Sarcomata differ from carcinomata in that a single rather than a repeated or more chronic injury is liable to precede their development. In a large series of cases there are the most varied intervals, ranging from

a few days to a year or more between the trauma and the appearance of the tumour. The interval between the injury and the appearance of the pain or tumour is about one month in approximately one third of all cases of osteogenic sarcoma.

The general condition is good until a late stage in the disease although night pains may keep the patient in misery and cause rapid deterioration of his general condition. Occasionally there is pyrexia accompanied by leucocytosis. The clinical picture in the terminal stages is unlike that seen in carcinoma. The patients tend to be anemic rather than cachectic, their haggard pallid appearance is characteristic. The skin too reacts differently it preserves its mobility and natural colour for a long time and becomes stretched instead of infiltrated as in carcinoma. Dilated veins may be evident at an early stage.

The size shape outline and consistency of the tumour are well perceived on palpation. Occasionally when the periosteal capsule is thin there is crackling. In very vascular tumours a pulsation and bruit can be felt. The rapidity of growth and the increase of size depend on the malignancy but after the periosteal capsule has been perforated the rate of growth increases rapidly. Pathological fracture is not typical of osteogenic sarcoma since the swelling and pain usually keep the patient off his feet. There may be some initial pain and effusion into the nearest joint but movement is free and painless.

Later general dissemination of the tumour takes place. While the lymphatic stream occasionally plays a definite role spread by the blood vessels is predominant. Pulmonary metastases are the most frequent. The first clinical signs of these are usually those of a diffuse bronchitis but occasionally the cough dullness fever and leucocytosis suggest a diagnosis of pneumonia.

DIAGNOSIS

Codman in a recent article laid down certain criteria for establishing the diagnosis in such cases. Definite cases of malignant bone sarcoma will show every one of these points although occasionally one or two of them may be doubtful absent or impossible to verify.

A. Points in the History

(1) In regard to the onset of the condition Codman states that unless pain precedes other symptoms it is doubtful if the case is one of osteogenic sarcoma.

(2) *Duration* If the patient seeks advice in less than a month or more than a year from the onset of the symptoms the case is probably not one of osteogenic sarcoma.

(3) *The General Condition* The patient is invariably in good health just before the onset.

(4) *Age* It is not usual to find the osteogenic type over the age of 50.

(5) *Rapidity of Growth* The growth may be exceedingly slow in

the enlargement is only noticeable month by month. If growth is more rapid a sarcoma is improbable.

B Examination of the Case

(1) *Immobility of Soft Parts* If there is obvious mobility of the soft parts over the tumour bone sarcoma may be excluded.

(2) *Location* If the tumour is not in one of the common sites bone sarcoma is unlikely the unlikelihood being in inverse proportion to the frequency of the occurrence at the site.

(3) *Inflammatory Signs* If the signs of inflammation are absent or very mild we may suspect that the case is one of osteogenic sarcoma. These inflammatory signs however are not unusual in Ewing's tumour.

(4) *Condition of Neighbouring Joints* Neighbouring joints should show free movement.

(4) *Size and Shape* If the tumour is not of considerable size or if it is pedunculated we may suspect it is not an osteogenic sarcoma.

C X-ray Appearance

1 The osteogenic type usually shows both medullary and subperiosteal involvement.

2 If the X ray does not show the old cortex or fragments of it in normal position we should suspect that the case is not one of osteogenic sarcoma.

3 A *sharp* outline of the tumour against spongy bone may make us suspect that it is not a sarcoma.

4 Unless the X ray shows both osteolytic and osteoblastic changes we should be suspicious that it is not a sarcoma.

5 A tumour that does not show in the X ray film either invasion of the soft parts or the reactive triangle is probably not an osteogenic sarcoma.

D Microscopical Criteria

1 Absence of mitotic figures should arouse suspicion that it is not osteogenic sarcoma.

2 Absence of pleomorphism is against it being a sarcoma.

3 The presence of tumour giant cells is necessary for a positive diagnosis.

4 The evidence of quite complete differentiation should make us suspect that it is not an osteogenic sarcoma.

TREATMENT

In bone sarcoma as in other malignant tumours the question of treatment is still an open one. As a rule the tumours are fatal and no therapeutic method of preventing death from this disease is known. It may be an exaggeration to say that a tumour from which a patient has recovered is not a malignant bone tumour but in such a statement there is probably more truth than error. Cases of osteitis fibrosa, skeletal syphilis and other bone lesions are often erroneously interpreted as sarcoma.

Of all the various attempts at *specific therapy* there is left to day only Coley's mixed toxins. The idea underlying these toxins is active immunization of the patient. After long experiments with numerous preparations of various streptococci with and without the combination of bacillus prodigiosus, Coley has now a standard method of preparing his toxin. A ten day old agar culture of *B. prodigiosus* is sterilized by heat and added to a sterile three weeks old streptococcus broth culture in the approximate proportion of 100 c.c. streptococcus 30 c.c. suspension of the prodigiosus culture and 20 c.c. of glycerin. This preparation is introduced subcutaneously or into the substance of the tumour. Coley believes that if after four weeks of intensive treatment with the toxins no marked improvement is registered then the expectation from this therapy is poor, but when there is a response to the treatment he recommends its continuance for at least a year. The usual reaction is fever, chill, dyspnoea, vomiting and general malaise. The literature and the material of the Registry of Bone Sarcoma are not so enthusiastic as Coley himself over the results.

It is safe to say that nothing has been achieved in bone tumours from *chemotherapy* although a 10 per cent. formalin solution is occasionally used as a deodorant.

Until recently operation has been the method of choice. Some surgeons amputate at the slightest suspicion, others amputate only as a last resort. Even with early amputation cure is unlikely. Cases of osteogenic sarcoma are often seen in which in spite of the fact that an amputation was performed immediately after the subjective onset of the disease death has followed from pulmonary metastases. It appears that dislodgment of emboli from malignant bone tumours is incomparably more rapid than in malignant tumours in soft organs. An exploratory operation may be carried out prior to amputation. There must also be absence of clinical evidence of metastatic spread. For this a radiological examination of the lungs is required. The question of conservative or radical surgical treatment always arises. Mikulicz advises tumour excision and bone resection, rather than amputation or disarticulation.

It is true, however, in these days of high development of prosthetic surgery that the patient becomes more efficient after an amputation than after a crippling sectional resection of bone. In connection with the latter there are dangers of overlooking diseased tissue so that for the sake of post operative efficiency, amputation is to be preferred to any conservative treatment, unless the tumour involves a region for which no satisfactory artificial limb can be fitted, while if the main blood vessels are surrounded by tumour it is obvious that the only choice is amputation. Modern surgeons, as a rule prefer amputation to resection or excision.

Recent advances in technical knowledge and in the application of radiation—X ray and radium—in the therapy of malignant tumours in general requires a revaluation of all accepted principles and traditions.

as far as the treatment of bone sarcoma is concerned. Radiation therapy is still in the experimental stage, and unfortunately it is being exploited by incompetent and unqualified workers. An error in technical application may do far more harm than good. It may stimulate the tumour growth and damage the normal structures of the organism and may even lead to ankylosis of joints and ulceration of skin.

Radiation leads to a conversion of a cellular tumour into a quiescent bony mass which in large vascular tumours may contain hemorrhagic cysts and necrotic material. The cessation of growth however, may be only temporary and the patient may die from a local recurrence or from pulmonary metastases. Radiation has been successful in the treatment of the tumour itself and also of the pulmonary metastases but frequently it only checks the growth. From the above it will be seen that there is no generally accepted routine solution of the problem of treatment of osteogenic sarcoma.

Kolodny advises the following in a patient with a typical non-sclerosing osteogenic sarcoma. Immobilization of the extremity and recumbency are followed after a few months of efficient radiation by amputation. Moderate prophylactic radiation of the chest is to be continued throughout the whole course of the disease care being taken to avoid over radiation. In far-advanced cases immediate amputation may give the patient a few months respite from invalidism and agonizing pain.

3 Angio-Endothelioma

This is a very rare tumour the American Registry containing only two cases. It occurs in patients of any age and apparently any bone in the skeleton may be affected.

The CRINICAL COURSE of the tumour is similar to that of osteogenic sarcoma save that the pain is later in appearance. Eventually widespread metastases appear death usually resulting from pulmonary involvement.

PATHOLOGY

The tumour is distinguished by its vascularity. The cells are large and polyhedral and may be arranged in solid alveoli or arranged as tubules round a central lumen containing blood corpuscles. The lining of these tubules simulates vascular endothelium.

DIAGNOSIS

The tumour is usually diagnosed as an osteogenic sarcoma its nature being apparent only on histological examination.

TREATMENT

The treatment is similar to that for osteogenic sarcoma but the prognosis is hopeless.

4 Endothelial Myeloma (Endothelioma Ewing's Tumour)

Ewing's tumour is of comparatively recent recognition but is now a well defined clinical entity. At first imagined to be rare there are now records of 162 cases in contrast with 722 cases of osteogenic sarcoma in the American Registry of Bone Tumours and it has been suggested by Campbell that many people dying of prolonged sepsis from osteomyelitis are probably suffering from this tumour ✓

It usually occurs between the ages of 5 and 15 and is somewhat more common in males. The bones most commonly affected are the long bones and of them it is more frequently found in the tibia. Next in frequency the fibula the humerus and the femur are involved. The tumour has a decided tendency to the involvement of other bones after the primary focus has been established indeed it may be diffused throughout the whole skeleton and the skull and small bones may be affected. Regional lymph glands may be involved ✓

MORBID ANATOMY

The tumour almost invariably begins in the marrow about the middle of the shaft a feature that serves to distinguish it from the osteogenic and benign giant-celled tumours. In colour it is greyish white and has a semi-fluid brain-like consistence. Areas of necrosis and haemorrhage with cyst formation are often present. The lamellae in relation to the tumour mass are destroyed and the appearance of the diffuse semi-fluid greyish tumour tissue amongst necrotic lamellae suggests osteomyelitis.

From the medulla the tumour extends in the Haversian canals to the surface. The periosteum undergoes a protective reaction and layers of new bone are deposited only to be destroyed. Such shells of new bone are deposited parallel to the shaft of the bone, and have been aptly described as onion layers.

HISTOLOGY

The microscopic structure of the tumour is simple. It is composed of small round or polyhedral cells arranged in solid masses and usually with scanty intercellular substance though occasionally the cells are lying in a delicate reticular network. More rarely, the tumour cells may be arranged round blood vessels or necrosis and haemorrhage may give the appearance of cysts. The nuclei are hyperchromatic and there is usually rapid mitosis.

Despite the bone destruction giant cells or osteoclasts are never found nor is new bone to be discovered apart from the subperiosteal deposits. The vessels of the tumour and the lymphatics may both contain obvious emboli for the tumour spreads by the blood and lymphatic systems. The regional lymph nodes may thus be affected,

in which event the histological picture is similar to that of the parent tumour

The Origin of Lwing's Tumour It is the fashion at the moment according to Platt to regard this tumour as an endothelial myeloma in that way emphasizing its possible origin from the cells of the bone marrow. By other workers it is thought to originate in the endothelium of the blood spaces of the marrow i.e. to be a true endothelioma. Husch and Ryerson in 1928 reported a tumour of similar pathology in which death resulted and autopsy demonstrated a primary epithelial tumour in the lung. Later Willis supporting this view suggested that the so called bone endothelioma was invariably metastatic often from a tumour of the adrenal medulla. This view may be dismissed for there

are authentic cases of cure following early amputation of the local bone lesion while in other cases there has been a long period of remission two features which would be most improbable if the tumour was already a metastasis.

CLINICAL FEATURES

Despite assertions to the contrary this tumour runs a protracted course and even where many bones are affected death may be long delayed.

There is usually a history of preceding trauma often associated with pain after an interval the pain subsides and the trauma may be forgotten about. Later on however there occur intermittent

attacks of pain followed by the appearance of a slow growing tumour in relation to the shaft of one of the long bones. During the attacks of pain the tumour may enlarge visibly and there may be febrile attacks and a leucocytosis. In the succeeding quiet intervals the tumour may appear to shrink in size (Platt).

The overlying skin is never affected unless surgical exploration is carried out during one of the acute phases then the tumour may fungate through the skin. Pathological fracture seldom occurs.

In the late stages multiple deposits appear in the skull ribs sternum pelvis and other long bones. There is then marked cachexia and secondary anaemia. When the vertebrae are involved there is severe root pain or paralysis and death usually results from metastatic involvement of the lungs.



FIG. 99.—Ewing's Tumour of Bone

X ray appearances There is a diffuse rarefaction towards the centre of the shaft and extending for a considerable area. In the early stages there is condensation without other change. Later from reactive irritation the periosteum throws off onion skin layers parallel to the shaft and rather like osteomyelitis. The last stage is that of gross tumour formation with destruction of the original bone structure.

DIFFERENTIAL DIAGNOSIS

There is a better prospect of cure in Ewing's sarcoma than in most of the tumours of bone. It is all the more essential that a diagnosis be made as early as possible.

Confusion may arise in connection with acute and subacute inflammatory lesions of bone especially

- (a) Pyogenic osteomyelitis
- (b) Sclerosing non suppurative osteomyelitis (Garré's osteomyelitis)
- (c) Syphilitic osteomyelitis

In (a) there is usually a primary staphylococcal lesion such as a boil or impetiginous spot. There is usually redness and oedema of the overlying skin and ultimately cellulitis. The X ray may show sequestration.

In (b) the tibia is usually affected but the symptoms differ from Ewing's tumour in that they are first severe and later become milder as the disease settles down to a more chronic state. The X ray picture is distinctive in that there is a localized area of dense sclerosis and the medullary cavity is usually completely obliterated.

In (c) there is seldom enough bone change to give rise to an appreciable clinical tumour. The pain is mild or tends to be nocturnal in its severity. The radiogram shows dense sclerosis and the Wassermann reaction is positive.

In order to check the diagnosis of Ewing's tumour it may be necessary to resort to biopsy or therapeutic radiation. In the latter cases the rapid shrinkage of the tumour and the amelioration of pain are so marked and constant as to afford a convincing therapeutic test which is less liable to danger and mistake than biopsy.

TREATMENT

Deep X ray therapy may cause the local lesion to disappear but there is considerable evidence to show that subsequent local recurrences often take place. It is probable therefore that primary irradiation should be followed by amputation and that by a further period of X ray therapy.

5 Multiple Myeloma

This is a rare disease characterized by the development in many parts of the skeleton of swellings varying in size from a bean to an orange. The bones most frequently affected are—the ribs, the sternum, the skull, the vertebrae, the pelvis and the femora.

PATHOLOGY

The affected bones show replacement of their marrow by grey or reddish grey tumour masses which tend to be circumscribed and oval in shape. The bone trabeculae and adjacent cortex are completely destroyed and there is no reactive new bone formation so that the tumours bear a close resemblance—on inspection as well as on radiological examination—to diffuse carcinomatosis. Hemorrhage with cyst formation is common and pathological fracture is frequent and often precedes extension of the tumour to the soft parts overlying it. When the disease is extensive there may be gross restriction of the absolute amount of red marrow so that anemia arises.

HISTOLOGY

The microscopic appearance of the tumour is very variable. The cells are usually diffusely arranged and are usually round cells. There is no intercellular substance. In some instances the cells resemble plasma cells—non granular mononuclear cells with deeply staining basophilic cytoplasm. In other cases the cells resemble lymphocytes or more primitive members of the white cell series. Nucleated red cells (erythroblasts) have also been reported as forming the bulk of certain myeloma tumours.

In view of the different histological structures found myeloma has been classified into four groups according to the predominant type of cell.

- (a) Plasmacytoma
- (b) Lymphocytoma
- (c) Myelocytoma
- (d) Erythroblastoma

The Origin of Multiple Myeloma This condition is usually regarded as a tumour of blood forming tissue a view supported by the frequent co existing enlargement of the spleen and lymphatic nodes.

CLINICAL FEATURES

The disease is one of adult life and chiefly affects males between the ages of 40 and 60. A history of trauma preceding the development of individual local lesions is often obtained. Pain is a late feature. Fever may be observed in the course of the disease and pathological fracture is not infrequent. Additional features may appear depending on the situation of the tumour. Thus when the vertebral column is affected cord pressure may arise.

In the late stages there is extensive cachexia and secondary anemia. Death as a rule occurs from visceral metastases but the lungs are not usually involved.

X-ray Appearances The tumours appear as multiple circumscribed areas of destruction in which the bone texture has completely disappeared. The cortex shares in this obliteration.

DIAGNOSIS

The multiple nature of the lesions the absence of pulmonary metastases the late age period and the characteristic X ray picture usually make the diagnosis clear

Difficulty may sometimes arise in distinguishing between the multiple



FIG. 100.—Myelomatosis of the femur, etc.

Note the true solid appearance with no "expansion" of the shaft the fracture of the neck and the "puffing" of the ilia.

myeloma and diffuse secondary carcinoma. In the latter there is usually a demonstrable focus in the breast, thyroid, prostate, or uterus. Biopsy may make the diagnosis clear and help may be obtained by demonstrating the presence of Benz-Jones proteose in the urine—albumosuria. It must be recalled, however, that this test is not

infallible for the protease is absent in fully half the cases. Further it also occurs in leukaemia in secondary tumours of the skeleton occasionally and rarely in nephritis.

TREATMENT

The only line of treatment available in multiple myeloma is deep X-ray therapy. The prognosis however is hopeless.



FIG. 101. Multiple Myeloma of the Skull

SYPHILITIC DISEASE OF BONE

While syphilitic affections of bone occur both in the secondary and tertiary periods of the disease they are more common after a number of years and are more grave in the tertiary stage. They differ from tuberculous affections in that the shaft is more frequently attacked, while the joints usually escape. The inflammation is the result of the presence of the *Spirochaeta pallida* and the irritation of its toxins and the granulation tissue that develops from this inflammation differs from ordinary granulation tissue in that the leucocytes are chiefly of the lymphocytic variety. This granulation tissue may undergo complete resolution especially where anti-syphilitic treatment is carried out at an early stage but if the resolution is delayed long enough,

well formed connective tissue—either fibrous or osseous—may develop. In some cases the granulation tissue may be of such a delicate nature that it dies before any attempt at organization has occurred, and a gumma is formed, such gumma formation results from a general lowering of the vitality of the tissues due to the disease itself, and from the fact that many of the vessels in the perishing tissue are occluded by the proliferation of their endothelial lining—a change peculiar to syphilis.

Causes of the Bone Lesions.

Bone-marrow is one of the chief seats of the syphilitic virus and gives the most constantly positive evidence of its inoculation, but notwithstanding this widespread infection of the bones, it does not by any means follow that a definite specific lesion will develop, the virus may be held in check till some influence, often a local one, upsets the state of equilibrium. Traumatism or exposure to cold and damp may serve the purpose, and so we find that the tibia, the femur, the humerus, and the cranial bones which are more exposed to such harmful influences, are the favourite seats of syphilitic trouble.

The Lesions in the Long Bones

1. **The Periostitic Node.** This characteristic lesion is a localized swelling of the shaft, oval or fusiform in shape, which involves usually a portion of the circumference, and may, indeed, even surround the bone. The bone most commonly affected is the tibia, which is often thickened for a considerable portion of its length, and usually upon its subcutaneous surface, the swelling shading off as it passes under the muscles. The sharp anterior crest of the tibia is replaced by a rounded surface, whilst the other borders are also apt to lose their definition, and the thickening may be so pronounced in front as to give rise to the impression that the bone has become bent. The femur, humerus and ulna are also frequently attacked.

Tubby has pointed out important points of differentiation between this curvature of the tibia and that seen in rickets.

| | Rachitic Curves. | Syphilitic Curves. |
|------------------------|-----------------------------------|--|
| Age | Generally under 3 | Occurs up to 15 |
| History | Signs of rickets present | Syphilis in parents, and signs of hereditary syphilis in child |
| Direction of curvature | Antero-lateral or antero-medial | Generally purely anterior (<i>Tibia en lame de sabre</i>) |
| Position of curve | Generally in upper or lower third | Middle of shaft |
| Crest of tibia | Sharp | Smooth and rounded |
| Surfaces of tibia | Flat or concave | Convex |

In dried specimens the surface of the new bone is grooved by an enormous number of vascular channels, evidence of the great vascularity

of the periosteum in the formative period. Later the vascularity disappears as the new bone gradually becomes hard and sclerosed.

These swellings in the early days are painful, tender and firm, but rarely show any inflammatory redness. As organisation of the new tissue occurs the swelling ossifies and becomes permanent. In its simplest form the node is a purely periosteal affection, but soon begins to attack the bone itself and spread into it. The compact tissue underlying the node is rarefied, then the cancellous tissue adjacent is involved, lastly the medulla of the central cavity is affected, and in due time the rarefaction gives place to a sclerosing osteitis.

The condition is nearly always a local one and is to be distinguished from the diffuse inflammatory condition to be described next, although more than one node may be found on a single bone.

2 Diffuse Osteoperiostitis. This is a chronic inflammation affecting the whole bone or the greater portion of it inside its periosteal envelope. All parts of the bone are involved, the condition apparently starting in the interior and spreading up and down to the extremities of the bone, and in young people—especially congenital cases—to the epiphyseal discs. It also spreads outwards through the compact shell, and evidence of periosteal inflammation appears upon the surface of the bone.

The diffuse character of the affection is due to the looseness of the medullary tissue which fills the spaces in the bone, and to the reaction produced in the medulla by the circulation of toxins in a feebly concentrated form.

A bone suffering from this generalized osteoperiostitis is heavier and harder than normal, and shows some periosteal deposit over the whole or greater part of its surface. The interior presents a uniform surface of densely sclerosed bone involving the cancellous and the medullary canal, and the compact bone with its periosteal thickenings. In younger cases the epiphyses may be irritated and a very marked increase in the length of the bone be produced.

In both types of this osteitis deep seated pain in the bone is apt to be specially troublesome, and at its worst at night when the patient is in bed it may be of such a distressing and intractable character as to make life almost unbearable. When anti-syphilitic preparations have no effect upon these pains relief may be obtained by gouging a trench in the bone and so diminishing the tension of the inflammatory products within the bone spaces.

Occasionally in both of these types on section or in an X-ray photograph a double outline is seen which is very characteristic of syphilis. A second sheath of compact bone overlies or surrounds the original compact layer, but an intervening space exists which may be filled with cancellous bone or granulation tissue. Such an appearance is due to the fact that the periosteum has been lifted from the bone by developing granulation tissue, and a fresh layer of compact bone formed on its under surface.

3. **Syphilitic Inflammation at the Epiphyseal Line.** **Osteochondritis.** Most children with congenital syphilis show an irregularity of the epiphyseal line, which results in the line becoming toothed, instead of being a straight line across the bone at right angles to the shaft. This irregularity is due to abnormal transformation of cartilage into bone, as a result of which not all the cartilage is changed into bone at the same time, but irregular lines of cartilage extend into the diaphysis.

Epiphyseal inflammation comes on at an early age, commonly in the first three months, and is one of the causes of so called syphilitic pseudo paralysis. It should be suspected when an infant during the first half year loses the use of one limb without apparent injury. The lower end of the femur is the commonest part to be affected, and is usually the first to be attacked when several epiphyseal regions are implicated.

There is as a rule some thickening about the epiphysis, pain on passive movement, and probably other signs of syphilis. Suppuration may take place and separation of the epiphysis result, but when this occurs it is probably the result of secondary infection.

4. **Gummatous Periostitis: Gummatous Osteomyelitis.** Syphilitic inflammation may assume the form of gumma, either on the surface of a bone, or in its interior. The condition is usually localized and may show no very definite boundary in either case.

The surface gumma resembles an ordinary periosteal node except that it speedily softens at its centre. The skin becomes inflamed and ulcerates, and the well known tough yellow slough is exposed. The slough slowly separates and exposes the bone which is found to be bare and either carious or necrosed. Caries is due to the rarefactive influence of the granulation tissue invading the bone, and necrosis to its caseation or to secondary septic infection.

A gumma in the interior of a long bone is a serious condition because it is apt to be mistaken for a malignant tumour. It may be responsible for spontaneous fracture.

5. **Syphilitic Dactylitis.** The importance of syphilis of the phalanges lies in the fact that it may be taken for tuberculosis. It is met with chiefly in children and affects any of the toes or fingers, but is commonest in the proximal phalanx of the index finger or thumb. More than one finger may be affected, and marked shortening and deformity result. Thickening, increased density, expansion, and even absorption of a bone may take place, and open sores may form. The lesion consists of a gummatous infiltration of the soft parts surrounding the phalanx or a gummatous osteomyelitis. There is little tendency to break down and ulcerate as in tuberculosis. The finger is swollen and though the movements are impaired the condition is usually painless. The diagnosis may be made from other signs of inherited syphilis. In its early stages the disease is amenable to antispecific treatment and complete recovery is the rule.

CHAPTER V

TUBERCULOSIS OF BONE

Tuberculosis of bone is one of the most serious and one of the most crippling of the maladies of childhood and for obvious reasons its economic importance is great. Its ravages are not confined to the early years and a fair proportion of cases occurs amongst adults.

ETIOLOGY

Certain features of the etiology are of interest. These are

- 1 The nature of the infecting organism
- 2 The route by which the bone is affected
- 3 The influences which predispose to the development of the disease

1 The Nature of the Infecting Organism The tubercle bacillus of bone infections may be either of the human or the bovine type and the relative percentage of each has been variously stated by different authorities. Fraser for example believes that 60 per cent of cases of bone tuberculosis result from the introduction of the bovine bacillus and this is in accordance with the opinion of other Scottish observers though Paul to whose sanatorium in Millport cases are admitted from Ayrshire and Renfrewshire thinks that even this percentage is too low. English authorities have found just the opposite. In Griffiths's experience 60-70 per cent of cases are of the human type and Morrison in 100 cases found 70 per cent of children and 82 per cent of adults had been infected with the human bacillus.

2 The Route of Infection Tuberculosis of bone is almost invariably secondary it is but a local manifestation of a general disease the original site of which is usually in the bronchial or the mesenteric glands. From the primary focus the bone is invaded usually through the blood stream but occasionally the bone infection is by contiguity from a neighbouring tuberculous joint or from infected soft tissues.

3 Predisposing Factors The factors which favour the development of the disease are general or local. The former may precipitate or make possible the infection of the subject with tuberculosis while the local factors favour its localization in bone. Among the general conditions may be included the leucæmætic diseases associated with considerable debility such as influenza and bad hygienic surroundings.

The actual incidence of the disease in bone raises interesting points. The resisting power of bone is high and the experimental production of tuberculous osteitis wellnigh impossible. This immunity of normal bone is due to the powerful resistance offered by the marrow, and it follows therefore that before the bone succumbs the natural defence must be broken down. In this connection it has been imply demonstrated that a tuberculous toxæmia is accompanied by a change in the marrow, which undergoes a fibro-myomatous degeneration the result of which is to diminish considerably the high degree of immunity.

With regard to the actual localization of the disease in individual bones a second important factor comes into play. Truax has shown that in certain bones and in individual localities of the bone a more direct cause is at work. The blood vessels which supply the bone become the site of a tuberculous endarteritis as a result of which the degenerative change in the marrow is aggravated and the liability to infection correspondingly increased.

The Influence of Injury A history of trauma is common and there seems little doubt that injury bears some relation to the development of the disease in the particular bone. The injury is usually slight. Extensive injury would be associated with such a profound reaction that there would be little or no chance of an organismal infection surviving. The slighter traumata are such, however, that they result in small intra osseous hæmorrhages or effusions, in consequence of which some degree of vascular stasis occurs. Such a temporary stagnation of the circulation favours the deposition of the organism in the injured area. Girdlestone thinks that local injury can be excluded from causal relationship with the lesion unless it occurred more than a month and less than six months before the development of the initial symptoms.

The Liability of the Different Bones The bones most commonly affected are the skull bones the short bones of the hands and feet the vertebra the tibia the ulna the femur and the humerus. The large proportion of skull bone infections is due to the relatively high occurrence of tuberculous mastoid or middle ear disease. It is interesting to note that infections of the bones of the hands and feet constitute about 25 per cent. of the remainder.

PATHOLOGY

The Site of the Infection The disease may originate in the centre, or at the periphery of the bone. In long bones like the tibia and the ulna it arises as a tuberculous osteomyelitis usually in the metaphyseal area for reasons similar to those which make pyogenic osteomyelitis particularly common in this situation. In short long bones, e.g. the phalanges the process often begins in the diaphysis owing it is usually held to the peculiarity in the arrangement of the nutrient vessel, which breaks up to form a network immediately it gains the interior of the bone in sharp contrast to its behaviour in the long bones.

in which it finally becomes plexiform in the metaphysis. In the ribs and in the skull the tuberculous infection is primarily a periosteal one while in the vertebrae it may commence either as a periostitis, or as an osteomyelitis in the centre or diaphysis of the bone. The epiphysis appears to be relatively immune to tuberculous infection but it does occasionally succumb especially when the disease extends from an adjacent joint.

The Sequence of the Pathology Reference was made above to the probability of a pre-existent fibro myxomatous degeneration of the marrow and the preceding endarteritis of the blood vessels. Under the influence of even a slight injury the weakened vessel walls are liable to rupture and produce a small extravasation of blood. In



FIG. 10. Tuberculosis of Bone.
Disease of the proximal phalanx of the middle finger. (See p. 17)

the resulting clot the tubercle bacilli settle down and eventually a typical tuberculous follicle is formed with endothelial cells, lymphocytes and giant cells. As the original follicle enlarges others appear around it and fuse with it until the combined mass is visible to the naked eye as a small white nodule in the centre of the marrow. Caseation later becomes evident at the centre while there is an attempt at fibrosis at the periphery. If the caseation is the predominant feature the disease in the absence of localizing fibrosis spreads, and the result is an infiltrating tuberculosis, while if the peripheral fibrosis is well marked the process is arrested and the result is localized or circumscribed tuberculosis.

Apart from the phenomena in the actual tuberculous nodule widespread changes are apparent in the various bony components

(i) The Marrow

During the early days of the disease immature polymorphonuclear leucocytes appear which later become fully developed. They are actively phagocytic and contain altered blood pigment. After a few days the polymorphs are replaced by lymphocytes and mononuclear cells whose presence is characteristic of tuberculosis. If now the disease becomes arrested fibrotic changes ensue. The lymphocytes disappear while the fat cells increase in number and young fibrous tissue appears in their midst. Fibrosed marrow is yellowish white in colour and firm in consistence. the microscopical appearance of the fat cells embedded in fibrous tissue has been aptly likened to that of a mosaic.

(ii) The Lamellæ

The lamellar tissue may undergo two types of change. There may be absorption or rarefaction (osteoporosis) or there may be thickening or increased density (osteosclerosis). Usually both processes are at work simultaneously.

(a) OSTEOPOROSIS. Rarefaction of the lamellæ is brought about either by true absorption of bone or by metaplasia. In true absorption, the osteoclasts appear beside the lamellæ and produce a series of tiny excavations known as Howship's lacunæ. Portions of bone over a large area are thus progressively removed and replaced by a fibro-cellular marrow and the individual lamellæ in this way acquire a worm eaten appearance. In metaplasia the lime salts disappear from the bone lamellæ, the fibrous elements at first persist but ultimately they merge into the fibrous tissue of the adjacent tuberculous nodule. Both those processes may occur in the same bone.

(b) OSTEOSCLEROSIS is the result of osteoblastic activity. The osteoblasts arrange themselves along the surface of the lamellæ and under their influence successive layers of new bone are deposited. The new bone is distinguished from the original by its greater number of bone corpuscles, and by staining a lighter colour. there is also a distinct line of demarcation between them. Osteosclerosis is characteristic of the chronic types of disease and tends to limit its progress.

(iii) The Periosteum

The increased vascularity of the periosteum is one of the earliest signs of tuberculous infection of bone, it is soon followed by subperiosteal thickening due to a deposit of new bone, which may be either porous or dense. Osteoclasts and osteoblasts are normally present in the deeper layers of the periosteum, and it is to their agency that the production of new bone is due. There is first an activity of the osteoclasts resulting in erosion of the surface of the bone which therefore becomes rough and irregular. The osteoblasts then proliferate and a thin layer of new bone is laid down on the uneven surface. The preliminary roughening of the bone surface diminishes the risk of the delicate new bone becoming dislodged. On the completion of the first layer a second is begun. numerous conical projections or spurs of

bone appear on the surface of the first layer, granulation tissue occupying the interspinous intervals. The extremities of adjacent spines fuse to form arches, and a layer of porous bone is thus laid down. The process is repeated until a series of such layers has been deposited, and the cir-



111 103 Tuberculosis of the Lower End of the Radius, with involvement of the Wrist Joint

cumference of the bone greatly increased. The whole process is an extremely ingenious one since it combines, as Frisier has pointed out, the maximum of strength and the minimum of weight.

Dense bone is formed in a similar way, except that in the second stage arches are not formed, and the bone remains compact throughout. This is the form of deposit that usually occurs in the neighbourhood of joints.

Macroscopic Varieties of Bone Tuberculosis

The microscopical changes described above are common to all forms of tuberculous lesion. In addition every case can be placed according to Fraser in one of the following macroscopic groups each possessing distinctive characteristics

- (a) Encysted, ✓
- (b) Infiltrating ✓
- (c) Atrophic ✓
- (d) Hypertrophic ✓

1 The Encysted Variety Here the diseased area has been shut off from the rest of the bone by a limiting wall of fibrous tissue. This is the commonest type of osseous tuberculosis and the most chronic

Macroscopic Appearance

The size of the follicle varies from a pea to a walnut. The centre is at first composed of jelly like substance through which opaque grey spots are scattered. Later, the central mass caseates, but an encapsulating shell of the original gelatinous matter persists, surrounded by a zone of pinkish white tissue merging at its periphery into the marrow. The marrow is congested but being otherwise little affected is in sharp contrast to the encysted nodule. In course of time the central tissue becomes semi fluid as the result of degenerative changes, so that the follicle ultimately acquires a cystic appearance. The lamellæ enclosed during the stage of active extension undergo rarefaction and absorption, the disease is so chronic that this is usually complete, but occasionally the absorption is imperfect necrosis occurs, and small sequestra known as 'bone sand' are formed.

Microscopically, the lesion in its early stages consists of a loose reticular follicle, corresponding to one of the grey pin point foci noted on naked eye inspection of the bone. The groundwork is composed of branching connective tissue cells and its interstices are filled with lymphocytes endothelial cells and usually giant cells.

2 The Infiltrating Variety This is the acute type of bone



FIG. 104.—Encysted Tuberculous Focus in Humerus

tuberculosis Nelaton pointed out that it occurs most often in enfeebled infants and in aged people in whom it actually appears to be the usual type

Macroscopic Appearance Three areas of the bone segment are visible

- (a) A central area composed of caseous debris This is pale yellow in colour and crumbles when touched and consists of the rarefied bony framework the interstices of which are filled with tuberculous debris Nelaton has accurately called it a pus forming infiltration



- (b) An intermediate zone of grey semi transparent tissue, merging imperceptibly into the central area and into the outer zone It is here that the tuberculous process is most active, there has been infiltration of tuberculous granulation tissue between the lamellae but it has not yet had time to caseate

- (c) Outside this grey zone there is a red band of congested marrow The transition is a gradual one, and frequently the line of junction is indicated by a strip of pale pink tissue which represents the area of invasion of the marrow by tubercle

Microscopic Appearance

The process is inaugurated as usual by the accumulation round the bacillary in bolus of clusters of endothelial cells These individual groups

FIG 10a.—Periosteal Tubercle of the Radius.

coalesce and a big area of diseased tissue is formed composed of lymphocytes and endothelial cells with a scanty amount of intercellular fibrous tissue About this time the diseased vessels become thrombosed probably as a result of the destruction of the endothelium Owing to the consequent arrest of the blood supply the resistance of

the follicle is diminished, and caseation begins in the centre. The coalescence of adjacent caseating areas produces the typical yellow appearance of the central area.

The process is so rapid that many of the lamellæ are not absorbed before the blood supply is finally cut off and are, in consequence, converted into sequestra. Indeed, when the disease is very rapid, a complete lamellar area may thus become necrosed to form a large sequestrum, which remains in contact with the surrounding bone until it becomes separated by granulation tissue. This form is known as a "composite" sequestrum.

Polymorphonuclear leucocytes collect around the periphery in the same way as in an acute pyogenic infection and for this reason it has been suggested that a mixed infection is the dominating factor in infiltrating tuberculosis. A modification of the process is sometimes seen in the form of a limiting fibrosis, and as evidence of this a pink band may be seen between the actual infiltration and the marrow. While these changes are taking place in the marrow, there is an associated activity in the periosteum which results in the formation of new bone on the surface of the shaft.

The characteristic features of infiltrating tuberculosis are therefore,

- ✓(a) The multiplication of endothelial cells and their aggregation into a dense mass
- ✓(b) The early occlusion of blood-vessels, by thrombosis due to destruction of their endothelium
- ✓(c) Early and rapidly spreading caseation
- ✓(d) Necrosis and sequestration before rarefaction is complete
- ✓(e) Little attempt by the tissues to circumscribe the process

3. The Atrophic Variety. The distinctive feature of the atrophic variety is the wasting and atrophy of the bone finally. This is seen most characteristically in caries sicca of the shoulder joint, where the original lamellæ at the upper end of the humerus are replaced by granulation tissue, and bone of a very fine texture is laid down on the surface, increasing the diameter of the shaft.

Macroscopic Appearance. The disease usually attacks the metaphyseal area of the shaft. The bone end is thickened, but is lighter than healthy bone, and its surface yields to moderate pressure with a peculiar crackling sensation. There is usually a thin layer of new sub periosteal bone, but on cross section the interior is seen to be composed of granulation tissue in which atrophied lamellæ are scattered. The granulation tissue is reddish in colour and throughout its substance there are numerous spaces which give it a spongy appearance. Similar changes may also be found in the epiphysis, even as far as the articular cartilage, which, however, is never itself involved.

Microscopic Appearance. The distinctive feature is the conversion of the marrow into a form of granulation tissue—a myxomatous connective tissue characterized by great vascularity and showing a strong tendency to cystic degeneration. Tuberculous follicles are scattered

throughout this mass and give the section a reticulated appearance Fibrosis takes place gradually

The lamellæ are rapidly absorbed through the agency of the osteoclasts the absorption beginning in the centre and extending towards the periphery making the bone extremely porous. The periosteum is similarly affected and a mass of highly vascular sub periosteal bone is deposited. As soon as the new bone is formed its deeper layers which adjoin the shaft are absorbed leaving a layer of granulation tissue between the shaft and the sheath of new bone. Thus although the circumference of the affected bone is increased its quality is highly defective.

4 The Hypertrophic Variety This is a rare form of osseous tuberculosis characterized by a lavish formation of new bone, or osteo sclerosis, and in many cases it results in the production of a large sclerosed sequestrum. It is possible that syphilis plays a part in this type of bone tubercle. Thickening of the lamellæ is the outstanding feature—in contrast to the atrophic variety in which absorption predominates. Like the atrophic form the disease is usually situated at one or other of the extremities of the bone.

Macroscopic Appearance The bone is diffusely thickened over an area extending from the junction of the diaphysis and the epiphyseal cartilage to about the middle of the shaft. The periosteum is easily detached and in the later stages there is a deposit of new sub periosteal bone. When the bone is divided transversely, its cut surface appears dense strong and sclerosed. The sclerosis which is not uniform is due to endosteal proliferation. In the centre of the shaft there is an area of grey semi fluid material embedded in which is a sclerosed sequestrum.

Microscopic Appearance

(a) **CHANGES IN THE BLOOD VESSELS** These are the first changes to be observed and the other effects arise in consequence of them. The vascular changes occur in the primary branches of the nutrient arteries near their origin the first departure from normal being the occurrence of an effusion of lymph round the vessel, producing oedema of the vessel wall, which begins to show some endarteritis. The effusion later becomes organized and converted into granulation tissue while the endarteritis progresses till the lumen is finally obliterated.

(b) **CHANGES IN THE LAMELLÆ** When the vascular changes have taken place the lamellæ surrounding the vessels undergo fibrous metaplasia and absorption in response to the disturbance of nutrition. The space formed by their absorption is occupied by fibro myxomatous tissue. Outside this central area of absorption sclerosis occurs from the deposit of new bone on the lamellæ by osteoblasts which have multiplied in the tissue lining the lamellar surfaces. This thickening is purely endosteal and results in firm dense bone.

The essential features, therefore, in the production of a hypertrophic tuberculous bone lesion are

1 The initial endarteritis, induced by the circulation of tuberculous toxins in the blood

2 Consequent disturbance of nutrition which results in absorption of the bony lamellæ surrounding the obliterated vessel, and their replacement by granulation tissue

3 Sclerosis of the peripheral lamellæ in response to the irritation caused by the central changes

CLINICAL FEATURES

Tuberculous disease of bone is insidious in its origin but steadily progressive. The disease may be considerably advanced before clinical evidence of its presence is obtained though often there has been evidence of tuberculous toxæmia for some time previously. The child may have been pale and easily tired or shown disinclination for his usual pursuits. The appetite may have been unimpaired and the mother may have noticed profuse perspiration during sleep—the so called 'night sweat' of tuberculosis. Ultimately certain features appear which are referable to the local lesion.

Local Signs

1 Swelling of the affected bone

2 Pain

3 Muscular wasting

The local swelling is at first soft and spongy corresponding to the stage of production of new spongy sub periosteal bone. Later the bone becomes hard. It may or may not be slightly tender to touch.

Local reddening of the skin and increased local temperature are uncommon.

✓ Pain is not an invariable accompaniment of bone tuberculosis, as the chronic progress of the disease precludes any great increase in intra osseous tension. In the early stages however, a serous effusion beneath the periosteum may give rise to considerable pain, and in the more acute types of the disease—the infiltrating tuberculosis type—pain may be held up in the medulla to such an extent that acute pain like that of a pyogenic infection results.

A third form of pain is occasionally present—a pain referred to the distribution of nerves which lie adjacent to the bone focus, and which are therefore liable to be irritated.

Muscular wasting is a constant feature in bone tuberculosis, but a proportion of this probably arises from disuse of the part.

The Course of the Disease The disease progresses slowly, and in the commoner forms excision occurs in the central portion of the shaft. Ultimately the pus extends peripherally and a sub periosteal abscess forms. If the disease is not checked at this stage the periosteum gives way, the tuberculous debris being extruded into the soft parts where, following the line of least resistance, it tracks along fascial planes to the surface. The skin overlying the abscess redens, becomes pro-

gressively thinner, and ultimately yields and in this way a tuberculous sinus is formed. If such a sinus becomes infected with pyogenic organisms the prognosis is grave. The child becomes more and more emaciated, the temperature is swinging and finally diarrhoea and albuminuria—evidences of amyloid disease—set in

Radiological Appearance The X ray appearance of bone tuberculosis varies with the type and the stage of the lesion but in all cases it must be remembered that the radiographic evidence lags behind the disease and there is thus a delay of it may be some weeks after the invasion of the part by tubercle before the X ray shows evidence of it.

In the encysted type there is a circumscribed focus usually in the metaphysis. The central region appears as a clear area all trace of its lamellar structure having been lost. The cavity may however contain a sequestrum. In the region of the focus the bone is usually rarefied and there may or may not be a deposit of sub periosteal bone.

The picture in the infiltrating type is less characteristic. There is a diffuse change consisting of disappearance of the lamellæ with here and there some cavity formation. There is almost invariably a deposit of new sub periosteal bone and there may be a composite sequestrum.

In the atrophic type the end of the bone is enlarged but is only a shell of its former self owing to the extensive absorption of the lamellæ. In the hypertrophic type on the other hand the bone is also increased in girth but the disease is usually situated at or about the centre of the shaft, and the density is considerably increased. There is little or no sub periosteal bone the sclerosis is endosteal and occasionally in the centre of the dense area there is a sclerosed sequestrum.

DIAGNOSIS

The diagnosis is reached after considering the history the clinical examination and the radiological appearances of the condition.

The history is of value in revealing a story of a gradual onset possibly some weeks after an injury and thereafter some interference with function and some swelling of the part and it may be pain. The family history may tell of other members infected or of some previous personal trouble with the same disease. There is usually a definite loss of weight health and energy.

Help may also be sought from the various specific tests—e.g. The Mantoux intra dermal test von Pirquet's cutaneous test, or the focal tuberculin test since if they are negative tubercle can be excluded. The sedimentation rate is of little value in diagnosis because of its non specificity. An increased rate tells us only that something is wrong in the organism but neither where nor of what kind.

If there is an abscess it should be aspirated and if neither cocci nor bacilli can be discovered the fluid is centrifuged and a guinea pig inoculated killed after six weeks and examined for signs of tubercle. In adults a biopsy of the part or of a regional gland is useful.

DIFFERENTIAL DIAGNOSIS

Tuberculosis of bone has to be distinguished from the following

1 **Syphilis of Bone** especially periostitis and osteitis. There is usually a history of syphilis or other signs of its presence while syphilis of bone is attended with severe pain. The radiological appearances are dissimilar and the Wassermann reaction positive.

2 **Chronic Osteomyelitis**. In this condition acute or subacute exacerbations occur at intervals with fever and local inflammatory signs. On radiological examination there is more or less sequestration more sclerosis and less new bone formation.

3 **Sarcoma**. The osteogenic sarcoma forms a uniform and more localized swelling at the bone end. Its growth is rapid and associated with pain. Local crackling is common.

The fibro sarcoma is also of rapid growth and pain a marked feature. In either case the radiological evidence should prevent confusion.

PROGNOSIS

In the average case the outlook is good for there is a strong tendency to natural limitation and strangulation of the focus. The disease is more grave when it affects the very young, when it involves the skull or spinal column and when sinuses form and become secondarily infected. Death is usually due to tuberculous meningitis miliary tuberculosis or amyloid degeneration.

The sequestration rate although of no value in diagnosis is useful in the prognosis since any variations in it depend upon degrees of tissue destruction. A rising rate means increase of tissue destruction and accordingly in the proved tuberculous case a spread of disease. A falling rate means decrease of tissue destruction and consequently healing. It is therefore of great value in assessing progress. Usually it merely confirms one's clinical impressions but in certain areas notably the lungs it is interesting to note that it is often an early pointer to something going wrong before clinical signs develop.

In this section reference should be made to the great improvement in prognosis that has attended the efficient sanatorium regime now practically universal in this country. The slow but progressive improvement in milk supply should also do much to lessen the incidence of bone tuberculosis.

TREATMENT

An adequate discussion of the best treatment of bone tuberculosis is beyond the scope of this book but reference may be made to certain essential factors.

The General Measures. General treatment is carried out on the usual line. If possible the patient should be nursed in a sanatorium setting which strict attention must be paid to improving the home surroundings and maintaining a high level of body hygiene.

The diet should be liberal and must include a high proportion of fats in the shape of butter, cream and milk

Drugs find little place in the treatment of tuberculosis. Cod liver oil, however is useful and other tonics may prove of some service. Exposure in the open air to the sun and wind is the most valuable part of general treatment and its value probably lies in the stimulation of metabolism by the variations of temperature and by the stimulation of air movement on the exposed body surface.

If there is evidence of co existing syphilis this should be treated. bismuth and arsenic have been suggested in this connection



FIG 106—Sunlight Therapy

The Local Measures It may be said that there are two schools of thought regarding the local treatment of tuberculosis in bone—the conservative and the operative. It is generally held that operation should be resorted to only under certain well defined conditions these will be alluded to subsequently.

The Conservative Treatment This consists essentially in the complete fixation of the affected part in the hope that rest combined with general measures will favour the arrest and cure of the disease.

The usual methods of fixation are

- 1 Plaster of Paris.
- 2 Celluloid splints
- 3 Metal splints

Plaster of Paris is cheap adaptable to almost any region and affords complete immobilization it is the method most favoured. If sinuses are present it has the obvious disadvantage that the discharge

collects under the rigid case. In this connection it should be said that Soleri in Italy considers this an advantage, in his words: "The benefit of the method lies in the fact that there is an auto-vaccination by specific products of the tuberculous pus in contact with the broken skin around the fistula under the apparatus." The principles of his method are similar to those of Orr in the treatment of acute osteomyelitis.

Whichever method is employed, the immobilization should include the joints above and below the affected bone and should be continued until the focus is completely healed, as evidenced by radiological examination. The minimum period of fixation should be one year.



FIG. 10.—Tuberculosis of Bone. Treatment by Artificial Sling.

This prolonged period in bed may produce certain reactions. Renal calculi result from the stagnation of urine in the pelvis of the kidney and may show themselves by low pain and hematuria. They may be prevented by drinking larger quantities of fluid—up to 4 or 5 pints daily—and by turning the patient or tilting him at reasonable intervals so that his stagnant pool may be emptied.

Operative Treatment

Operation may be indicated

- (a) When the disease is progressing despite conservative treatment
- (b) When conservative treatment would of necessity be prolonged
- (c) When there is a large sequestrum liable to result in the formation of a cold abscess and a continued discharge
- (d) When there is secondary infection

Operation is contra indicated when the patient is under the age of 2 or when miliary dissemination has occurred

The Operations These consist of—

A Gouging or curettage of the diseased focus

B Resection of the affected segment of bone

(i) Curettage The affected portion of bone is freely exposed the periosteum separated and the affected medulla opened by trephine or drill. The interior is then thoroughly curetted. The resulting cavity may be treated in a variety of ways e.g. the insertion of iodoform packs bone chips or Beck's paste. The part is immobilized on a light removable splint till the wound heals. Thereafter a plaster case is applied and retained for three to six months.

(ii) Excision The bone is exposed and the periosteum detached to expose healthy cortex above and below the situation of the disease. The bone is divided on the diaphysal side of and some distance from the lesion and the fragment containing the focus pulled upwards to separate it from its periosteal bed. If—as is usual—the affected portion is the metaphysis the fragment is now wrenched away from the epiphyseal cartilage which is left behind attached to the epiphysis. Otherwise the bone is divided by saw or forceps and the affected portion lifted out. The periosteal tube is now repaired and a light splint applied until healing occurs. Thereafter the limb is encased in plaster which is renewed every three months until a new shaft has formed.

The gap is first filled with blood clot which later organizes to provide a scaffolding upon which new bone is deposited by the periosteum and the divided bone ends. The regeneration usually occupies at least nine months but as the bone is still weak at that time a light splint is continued until full weight bearing can be commenced.

TUBERCULOUS DISEASE OF THE VERTEBRAL COLUMN

(Pott's Disease Spinal Caries)

Tuberculosis of the vertebral column first described by Percival Pott and since associated with his name is a slowly developing disease characterized by post spinal deformity and occasionally paralysis.

INCIDENCE AND ETIOLOGY

Vertebral tuberculosis is essentially a disease of early childhood the majority of cases starting between the ages of 3 and 5 although in hospitals a great number are of an older age period owing to inefficient initial treatment and recurrences. It is commoner in boys than in girls. The symptoms are frequently attributed to injury where such injury is definitely a factor a slight trauma is considered more important than a severe one.

It is commonly found that children with Pott's disease have had tuberculous parents but on this point statistics are unreliable. In some cases the infection may pass directly from parent to child. Severe

debilitating affections such as the exanthemata render the child more liable to tuberculosis, but not more so in the vertebral column than in any other situation

PATHOLOGY

Sites of the Disease. Spinal tuberculosis is met with most frequently in the lower thoracic region. Out of a total of over 1,000 cases admitted to East Fortune Sanatorium the spine was involved in 30 per cent of the cases of bone and joint lesions. Out of 1,284 cases, Whitman found 100 in the cervical, 854 in the thoracic, 317 in the lumbar, and 13 in the lumbosacral segments, and Fraser states that in 51 per cent. of cases of spinal caries, the disease is situated in the region of the tenth, eleventh and twelfth thoracic, and the first lumbar vertebrae. He suggests that this distribution is the result of certain definite influences. In the past, these factors have been considered to be the relatively large amount of spongy tissue in the vertebral bodies, the degree of weight-bearing, and the extent of movement demanded of this portion of the column. Fraser points out that underlying this explanation is the assumption that the infection is a blood-borne one, but suggests that the importance of the prevertebral lymphatic tissue has been under-estimated. He recalls the fact that the thoracic duct is virtually in contact with the anterior surfaces of the vertebrae at that level, and that into it most of the abdominal lymphatics discharge. Since the tubercle bacillus not infrequently gains entrance to the body through the abdominal glands and lymph vessels, it may well be that the close proximity of such an obvious source of infection as the thoracic duct is responsible either for the actual tuberculous infection of these vertebrae, or for a series of degenerative changes which predisposes these bones to the later development of the disease.

At an early stage it is not possible to say how many vertebrae are infected even on a radiogram. Double lesions with intervening normal vertebrae are found in 5 to 10 per cent of cases. Tuberculosis in other parts of the body is seen in about 10 per cent of cases, about half of these being the subject of pulmonary disease.

Varieties. The following varieties of vertebral tuberculosis are commonly recognized.

(1) The Central, in which the spongy tissue of the body is affected. The author believes this to be the least common, especially in children.

(2) Epiphyseal Tuberculosis (intervertebral articular type) where the disease arises in the epiphyses of the body and, therefore close to the intervertebral disc. The infection in this, the commonest type of disease, is chiefly on the disc side of the epiphyses. The disc is infected at an early stage and is rapidly narrowed.

(3) The Anterior or Periosteal variety, where the primary focus is deep to the periosteum on the front of the body, beneath the anterior longitudinal ligament.

(4) Appendicular Tuberculosis. Occasionally the transverse process is affected, and, more rarely the vertebral arch.

The Sequence of Pathology The disease begins as an infection of a single vertebra and each of the component tissues is ultimately involved. The primary error is a nutritional disturbance of the marrow following a tuberculous arthritis. the marrow is converted into pale myxomatous tissue which provides the ideal pabulum for the growth of the tubercle bacillus. In the devitalized tissue the bacillus settles down and a typical tuberculous follicle develops until it is visible to the naked eye as a small yellow grey nodule. As this nodule grows the lamellae over a wide area are progressively rarefied and eventually

disappear. Since the strength of the vertebra depends on the internal structure of its body it follows that with the disorganization of its lamellar structure its strength is seriously compromised especially as there is practically never any subperiosteal new bone formation save in the later stages. Indeed in the vertebral column tuberculosis seems to exercise an inhibitory effect on new bone formation in contrast to the long bone in which the deposit of new bone is a striking feature. As Girdlestone says osteogenesis does not occur except at a distance in time or in space from an active tuberculous lesion.

To summarize these important phenomena

there is 1 diminution in blood supply 2 degeneration of the marrow 3 invasion by bacilli 4 absorption of the lamellae 5 central cavitation and 6 failure to deposit subperiosteal bone

The centre of the body being caseous the superimposed weight of the vertebral column is now borne by the fragile shell of compact bone which sooner or later collapses. An angular deformity—kyphosis, humpback, or hunchback—now results, for the neural arch is swung upwards on the fulcrum of the articular processes when the short arm lever of the vertebral system formed by the diseased body descends (collapses). As a result of the collapse the tips of the adjacent spines are widely

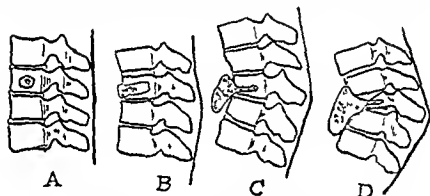


FIG 108—Tuberculosis of the Spine producing Angulation

separated. Such deformity is most marked in thoracic cases since owing to the normal dorsal curvature the weight is thrown chiefly on to the anterior part of the vertebral body which therefore completely collapses. In the cervical region collapse rarely occurs because the weight is transmitted chiefly through the articular processes. The deformity therefore is a comparatively slight one. In the lumbar region also the deformity is small, since, owing to the normal lumbar lordosis the body weight is borne chiefly by the posterior parts of the vertebral body, and collapse is incomplete.

Associated Changes

Abscess Formation When the body of the vertebra collapses there is expressed from it a collection of tuberculous detritus consisting of granulation tissue, caseous matter, disintegrated bone lamellae and bone marrow. This collection is known as a cold abscess, and is the commonest complication of Pott's disease. It is said to occur in



11-109—The Growth of a Tuberculous Focus in the Body of a Vertebra
Showing the collapse of the body and the gradual formation of the abscess.

20 per cent. of cases. At first, the debris collects under the anterior longitudinal ligament on the front of the vertebral body, where it may remain, but more usually it becomes further disseminated along one or several courses. It may pass backwards and invade the vertebral canal—a serious complication resulting in it usually does in pressure on the spinal cord. It may trick forwards and become diverted by various anatomical structures such as blood vessels, nerves or muscles. The abscess may therefore come to be situated at a considerable distance from the site of the original disease, and a knowledge of the possible situations of collections, and the factors which determine them is consequently of great importance.

Cervical Region The pathway traversed by tuberculous debris in disease of the cervical spine is determined by the attachment of the cervical fascia.

- (a) It may collect behind the prevertebral fascia in front of the vertebral body, constituting one variety of retropharyngeal

abscess ultimately such an abscess points at the posterior edge of the sterno mastoid muscle

(b) It may penetrate the pre vertebral fascia and so enter the mouth or one of the visceral compartments of the neck.

(c) It may track between the lateral surface of the vertebra and the posterior cervical muscles and perforating the deep cervical fascia appear on one or other side of the spinous process

(iii) Thoracic Region In thoracic Pott's disease the abscess is usually small and frequently remains in close contact with the spine not uncommonly it gives rise to paralysis from pressure on the cord. If the abscess is large it may extend in a variety of ways

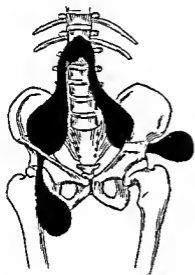


FIG. 110.—Abscess Formation in Pott's Disease

Diagram represents one of the various courses which a tuberculous abscess arising from the thoracic vertebrae may take (After G. S.)

(a) It may perforate the anterior longitudinal ligament and occupy the posterior mediastinum

(b) It may pass laterally through the pleura giving rise to a tuberculous empyema

(c) It may gravitate downwards beneath the medial arcuate ligament and assume the characteristics of a lumbar abscess

(d) It may track backwards between the transverse processes

(e) It may extend along the intercostal vessels and reach the surface either with the lateral or the anterior intercostal branches

(f) It may follow the course of the posterior primary division of the intercostal nerve or its branches. Occasionally a thoracic aneurysm under tension transmits the pulsation of the aorta to the spinal column below the area of disease

and an X-ray will show anterior erosion of the bodies just as in an aneurysm. This is known as an aneurismal syndrome

(iv) Lumbar Region

(a) A lumbar abscess may extend forwards to enter the sheath of the psoas, and may then gravitate downwards until it appears below the inguinal ligament on one or other side of the femoral vessels

(b) It may pass down in the sheath of the psoas, and then pass laterally deep to the fascia lumbra to appear just medial to the anterior superior spine of the ilium

(c) It may track forwards without entering the sheath of the psoas and infiltrate along the linea of the great vessels, thus it may accompany the external iliac and femoral vessels into the thigh or the hypogastric vessels into the groin of the pelvis

- (d) It may extend laterally into the sheath of the quadratus lumborum, and so become superficial above the crest of the ilium
- (e) It may follow the dorsal branches of the lumbar arteries, and point below the last rib close to the spinal column
- (f) The abscess may also follow the course of the posterior primary division of a lumbar nerve to point some distance from the middle line of the back

Pressure on the Spinal Cord

Paraplegia occurs as an unfortunate sequel to Pott's disease in 11 per cent. of cases according to the latest statistics those of Butler and Seddon. Age has little influence on the onset of paralysis although it is more commonly seen in childhood because of the relatively higher incidence of the disease at this age period.

Paraplegia is rarely met with in disease below the level of the first lumbar vertebra since the cord has terminated below this point and as thoracic disease is far more common than cervical disease the majority (85 per cent.) of paraplegias accompany thoracic lesions. In addition to the greater frequency of disease in the upper and middle thoracic region, the narrowing of the bony canal here and the difficulty in securing complete fixation during treatment increases the probability of paralysis.

The error responsible for the paralysis may arise in the bones, the membranes, or in the cord itself.

(1) Bone Causes. Pressure on the cord is a result of the annulation of the anterior wall of the bony canal may though rarely give rise to paralysis, and symptoms of cord compression may also arise in the presence of a partial dislocation of the vertebra. Secondly, the extension of tuberculous granulations into the canal or a cold abscess.

(2) Causes in the Membranes. When the meninges are at fault, the cause is usually a pachymeningitis, or more rarely a leptomeningitis, these result in thickening of the membranes and in obliteration of the blood and lymph vessels. Pachymeningitis was previously held to be a very common cause of paraplegia but Butler and Seddon found little evidence of this in their series.

(3) Causes in the Cord. The nervous tissue of the spinal cord is practically never infected with tuberculosis, any changes which it shows are secondary. Thus it may be flattened from pressure, or oedematous as a result of vascular stasis and may even become the site of subacute myelitis.

Because paraplegia of Pott's disease varies so widely in type and in duration classification has always been a matter of difficulty. The following account is based on the simple classification into three clinical types recently suggested by Butler and Seddon. It is a modification of that used by Sorel and is of value in prognosis and treatment.

(A) Paraplegia of Early Onset

Type 1. Paraplegia with early active disease arising, persisting, and recovering in direct relationship to the activity of the tuberculous

process. It usually occurs within the first two years, is typically a complete paraplegia, and if the patient survives recovery ensues.

✓ TYPE 2. Paraplegia having its onset with early active disease, but persisting permanently, even if the tuberculous disease has become quiescent. In most cases it is indistinguishable in its early stage from Type 1. It is complete at first and may show some degree of recovery before passing into a state of permanent paralysis.

(B) Paraplegia of Late Onset

TYPE 3. Paraplegia of late onset appearing at any time up to many years after the disease has become quiescent. When the paralysis appears there may or may not be evidence of activity of the tuberculous lesion. The paraplegia is almost always of a partial nature. With the passage of time this type is found to fall into one or other of two subdivisions.

(a) Recovery takes place under further conservative treatment as for active disease whether this is present or not.

✓ (b) No recovery takes place under any form of treatment.

Type 1 Paraplegia Temporary Paralysis of Early Onset

This type of paralysis is found in early active Pott's disease. Usually, the Pott's disease has been recognized before the paralysis, although sometimes the paralysis is the first trouble of which the patient complains. Even then however the Pott's disease may be recognized by slight deformity, local or referred pain and X-rays.

The onset is almost always within the first two years. The progress is usually rapid, being further accelerated by lack of treatment. ✓ Visceral weakness inco-ordination and spasticity appear first and progress to a paraplegia in extension, with increasingly frequent attacks of general flexor spasm, so that as the paralysis deepens it may become a paraplegia in flexion. ✓ Paraplegia in extension indicates an incomplete lesion of the cord, certain tracts having escaped compression. Where the paraplegia is in flexion the whole thickness of the cord has become involved and the prognosis is necessarily bad. In the worst cases of all spasticity may be lost and the paralysis may become almost completely flaccid and with such the outlook is always grave. Although motor changes are usually the first to appear they are sometimes preceded by changes in sensation which are of variable distribution but generally affecting the extremities first and most completely. ✓ Retention of urine and feces is a late feature. Later automatic action of the sphincters may become established or, in the most severe cases, the sphincters become completely paralysed and exert no control. Finally, with deepening paralysis much ✓ vascular and trophic change may be present in the extremities and in parts exposed to pressure, and the patient commonly dies from septic absorption from bed sores. ✓ In this type of paraplegia the condition can remain stationary for many months—certainly over a year—and then recover completely. Recovery is generally associated with and is sometimes preceded by clinical or X-ray evidence that the disease itself is lessening.

The usually accepted explanation of Paraplegia is that the cord is compressed mechanically by an abscess but Butler and Seddon believe that frequently the compressing factor is granulation tissue rather than fluid pus. They point out too that paralysis may occur in this type without true compression of the cord and in such cases the interference with cord function is due to the vascular and toxic reactions in the cord secondary to the neighbouring active tuberculosis.

Every case conforming to this type recovers completely under efficient treatment unless certain things happen

1 The initial infection may be so virulent that the patient dies rapidly of tuberculosis before the paraplegia has run its course

2 The disease persists for so long that the damage to the cord ultimately becomes irreparable and permanent

3 An accident occurs vascular or skeletal resulting in permanent damage to the cord

PREVENTION

As paraplegia is often the first evidence of spinal caries prevention is not always possible. The only measure applicable during the course of ordinary conservative treatment that is of definite value in diminishing the incidence of paraplegia is hyperextension of the spine. In this position the involved vertebrae tend to separate and are relieved from longitudinal pressure and the grinding resulting from the constant respiratory movements is reduced. As soon as activity has abated hyperextension should be discontinued and the diseased vertebrae allowed to fall together to some extent.

TREATMENT

The treatment of Type 1 cases is of almost every form of Pott's paraplegia is primarily conservative by means of fixation and some type of apparatus as will be described.

When spasticity becomes marked adhesive extension must be applied to the lower limbs and metal splints applied to hold the feet at right angles and the knees in extension. In the more severe cases extensions and splints are not tolerated owing to the uncontrollable spasm. In these cases the lower limbs must be left free and every joint put through its full range of movement twice a day in order to prevent the development of contractures.

OPERATION Although most cases recover spontaneously there are cases bordering on the Type 2 (continued activity of disease) group in which the paralysis is so profound and so prolonged that the patient is reduced to a condition of extreme misery and the surgeon to a state of constant anxiety. In these cases operation is of value, and is moreover certainly indicated when there is evidence of pressure on other vital structures such as the pharynx. Operation should not be delayed longer than six months after the voluntary micturition has been lost, although this duration of paraplegia is not necessarily *per se* an indication for operation.

The operations carried out at this stage are—lateral drainage of

the spinal abscess by co-sto-transversectomy in thoracic cases and incision of the abscess in cervical cases. Gratifying results may follow such operations, for there is an undoubted connection between drainage of the focus of disease and relief of the paralysis.

Type 2 Paraplegia Permanent Paralysis of Early Onset

There is a certain small number of paraplegias in which the paraplegia is of early onset and associated with early active disease, and which remain to a large extent permanently paralysed, these cases thus fall into the Type 2 group. This permanence of the paralysis is usually due to inadequate treatment in the early stages, but in some cases it is unavoidable and due to irretrievable cord damage from sudden mechanical or vascular disaster.

There are three clinico-pathological types of Type 2 paraplegia.

1 PARAPLEGIA OF SUDDEN ONSET RAPIDLY BECOMING COMPLETE. This may be due to collapse of a single vertebral body or to acute thrombosis of the cord. In both cases the striking feature is the sudden complete paralysis but in the former the concertina collapse can be demonstrated radiologically, whereas an X-ray of the latter shows nothing apart from the usual tuberculous lesion.

2 THE SPINAL TUMOUR SYNDROME. This condition is fortunately rare and resembles an extra-medullary tumour. The cord is damaged by granulations or pus and this is the only form of Pott's paralysis in which the neurological signs develop before there are radiographic changes demonstrable in the spine.

3 PARAPLEGIA WITH USUAL ONSET BUT PERSISTING IN SEVERE FORM FOR MANY MONTHS. Cases in this group are essentially Type 1 at first and gradually drift into Type 2. There are three possible explanations for the prolongation of the severe paraplegia and they will generally be revealed by the X-ray.

i Pathological Dislocation. Where the posterior intervertebral joints or the pedicles and articular processes are destroyed a pathological dislocation of the spine may take place with pinching of the cord.

ii Compression by Sequestra. If destruction of the vertebral bodies leads not only to the removal of bone but also to the formation of loose sequestra these may be forced back by the collapse of the other bodies into the vertebral canal, where they compress the cord.

iii Continued Activity of the Disease. Fortunately the signs of continued activity are very definite, and one or more of them is present in every case. They are—irregular fever, night sweats, X-ray evidence of extension of the bony lesion and increase in size of the abscess shadow and sometimes the appearance of fresh tuberculous foci in other parts of the body.

PREVENTION

Prolonged hyperextension of the spine is the only non-operative measure of any value in the prevention of Type 2 paraplegia. Unfortunately, the condition of the patient is sometimes so critical that this ideal method of nursing cannot be employed.

TREATMENT

In thrombosis of vessels supplying the cord and in consequent collapse of the vertebra no radical treatment is of any avail. Early laminectomy is indicated in all cases of spinal tumour syndrome, though it has yet to be shown that the condition may be completely cured by surgical intervention. Costo-transversectomy is indicated in all cases with continued activity of the disease and there is evidence to show that recovery will occur, provided that the operation is performed early and that the patient does not succumb to generalized tuberculosis.

No case of compression by sequestrum has yet been dealt with successfully by operation although theoretically it would seem to be possible to remove even a large sequestrum from the front of the cord by a large costo-transversectomy approach.

In pathological dislocation radical operative treatment may hold out some prospect of relief according to Butler and Seddon. They point out that the fragment of bone responsible for the compression of the cord is part of a vertebral body forming part of a bony ring encircling the canal. The integrity of this ring will depend upon the extent to which the pedicles have been eroded by the disease. If the anterior half of the ring is resected the cord will be liberated and this should be the aim of any operation designed for the relief of the condition.

Type 3 Paraplegia Paralysis of Late Onset

In this type the outstanding characteristics are the late and gradual onset, the incompleteness of the paralysis and the high proportion of permanent paralysis in comparison to Type 1.

The onset is very variable from a few months to many years after the apparent quiescence of the disease. Muscular spasticity is usually the first sign. Sensory changes may be lacking throughout but there is usually widespread but incomplete anaesthesia. Pain is rarely felt but there may be a little backache or irregular pains down the limbs. Loss of sphincter control is uncommon. Frequently there is loss of bladder control though the bowel is normal. Vascular and trophic changes are uncommon. Even at its height late onset paraplegia is typically incomplete and the legs are seldom devoid of slight voluntary power.

The usual history is that early in life the patient suffered from tuberculous disease of the spine as a result either of extensive disease or inadequate treatment or both. Bone destruction has been excessive and a number of vertebral bodies have been completely destroyed. The disease became healed and the patient led a normal life. Thereafter nothing unusual is noticed apart possibly from a slowly increasing deformity of the spine. Then after a long period which may be as long as forty years the patient complains of a little weakness of the lower limbs or inco-ordination when walking which marks the onset of the paraplegia.

Butler has shown that the majority of patients in this group are suffering from a recrudescence of the disease in the neighbourhood of

the spinal cord. In the minority there is evidence that points to stretching of the cord over a bony ridge in the floor of the spinal canal. It is most difficult to distinguish between the two varieties of causation, but a consideration of the following points may be of value.

1 There may be clinical and X ray evidence of active disease—further erosion of the vertebral bodies, the shadow of a recent abscess, or a fresh abscess discharging from the surface.

2 The absence of a bony ridge in the floor of the spinal canal clearly excludes bony compression but the converse is not always true, the presence of a ridge does not necessarily indicate mechanical compression.

3 If the patient is treated by a method that tends to decrease the angulation of the spine it would be reasonable to suppose that a paraplegia due to mechanical compression would either improve or remain stationary. If in spite of such treatment, the paraplegia become steadily worse the cause must be infective.

PROGNOSIS

75 per cent of the cases of this group under 16 years recover. In later years the prospect is not so good—about 50 per cent. The prognosis as regards life in late onset paraplegia is good. ✓

TREATMENT

The treatment of late onset paraplegia is essentially conservative. Prolonged rest in recumbency is necessary. Hyperextension is of very doubtful value and there are no rational grounds for applying it. Operative intervention may be considered but these cases are bad risks, whatever operation is performed on them. There is gross deformity of the chest, the vital capacity is diminished and there is generally some cardiac insufficiency. If a fresh paravertebral abscess is demonstrable costo-transversectomy is indicated, though generally the reactivated focus is confined to the spinal canal.

Laminectomy is usually the only hope, but since the integrity of the spinous processes and laminae is sometimes the only factor preventing gross dislocation of a severely damaged spine, the operation itself should always be combined with grafting. It is possible that operation will prove more successful in cases where the cord is stretched over a bony ridge and in these cases nothing less than the removal of the projection over which the cord is stretched will suffice.

Mode of Repair in Vertebral Tuberculosis

Healing of spinal caries occurs by the absorption of tuberculous debris and its replacement by fibrous tissue, a fibrous ankylosis occurring between the diseased bodies. Later ossification occurs, again principally in the region of the primary disease, to a lesser extent some new bone formation takes place in relation to the posterior arch, and adjacent laminae and pedicles may thus become fused together. The new bone is soft and yields easily, so that unless adequately protected it may be unable to withstand the superincumbent body weight even though the tuberculosis is completely eradicated. Thus it happens that under the strain of ill health or overuse the deformity

SUMMARY OF PREVENTION AND TREATMENT (SEDDON)

Type 1

Prevention
Not always possibleHyperextension of
definite value

Treatment

(a) Primarily conservative

(b) Costo transversectomy in any severe case likely to become Type 2 — continued activity of disease

(c) Incision of abscess in cervical cases particularly if there is pharyngeal obstruction

Type 2

✓ Acute thrombosis of vessels supplying the cord

✓ Constrictor collapse

✓ *Paralysis* & *granulation*

✓ Spinal tumour syndrome

Continued activity of disease

Compression by sequestrum

Pathological dislocation

Posterior spinal disease

Not possible

Hyperextension

Not possible

Costo transversectomy while still Type 1

Hyperextension

Hyperextension

Not possible

Operation contra indicated

Operation contra indicated

Laminectomy

Costo transversectomy

Removal of sequestrum should be attempted

Removal of bony ridge possibly of value

Laminectomy

Type 3

Efficient treatment of the tuberculous spine at every stage

Conservative. In severe cases, possibly laminectomy and graft, removal of tuberculous material or of bony ridge if mechanical compression is present

SUMMARY OF PROGNOSIS

A guide to prognosis is given, based on the neurological features of Pott's disease, irrespective of the cause (Seddon)

Very favourable

✓ Paralysis in extension
✓ Voluntary control never lost

✓ Voluntary control absent for not longer than 6 months

✓ Absence of sensory loss

✓ Absence of sphincter involvement

Unfavourable

✓ Sphincter involvement

✓ Urinary infection

✓ Pregnancy

Hopeless

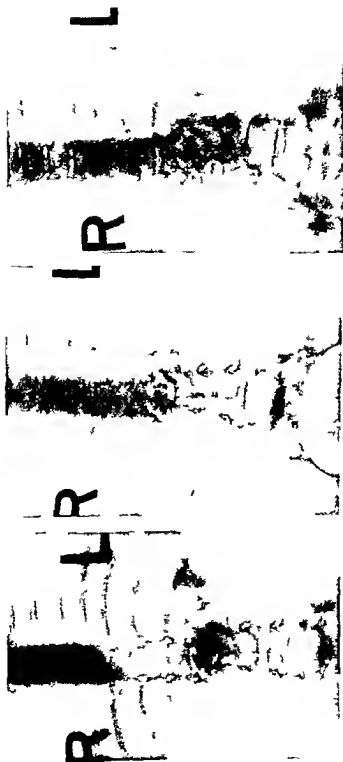
✓ Paralysis in flexion

✓ Flaccid paralysis (except in cauda equina and brachial lesions)

✓ Loss of voluntary control for longer than six months

✓ Loss of vibration sense

✓ Old age



(a)

(b)

(c)

Fig. 111.—Tuberculosis of the Spine

- (a) Disease, affecting the lumbar region with a typical Pigeon spine. A later stage—10 days later—of the disease. (b) The spine after 10 days of treatment. (c) The spine after 10 days of treatment. The spine after 10 days of treatment.

may actually increase and give rise to backache after the disease is completely healed. The cure of the disease in the lumbar region frequently results in complete bony union between two adjacent vertebrae with virtually no deformity.

SYMPTOMS OF SPINAL TUBERCULOSIS

Before the actual onset of characteristic local symptoms there is a prodromal period frequently preceded by one of the exanthemata. During this stage there is often some deterioration in the general health. There may be loss of weight a poor appetite and often an evening rise of temperature. These symptoms last for a few weeks or months but eventually the evidences of spinal trouble appear. These are

1. Pain. The occurrence of pain is usually the first indication of spinal disease. The pain may be either local i.e. experienced in the back or referred along one of the spinal nerves. In either case it is frequently severe because of the free and complex nature of the movements of the spinal column and because of the close proximity of the spinal nerves. When felt locally the pain is acute and stabbing and situated over the affected vertebra. It is increased by pressure on the spinous process, or by the rotation of the vertebra produced by pressing on the transverse processes.

Fraser suggests the employment of a visco-sensory reflex test to elicit the pain. If a coll sponge is drawn down the back over the tips of the spines sudden severe pain is experienced when it passes over the area of the disease.

The referred pain is referred to the distribution of the sensory nerves. It is less acute but exacerbations may occur. The skin areas supplied by the related nerves are hypersensitive to pressure.

In cases of the cervical spine the area of referred pain is usually situated over the occiput and in the arms. In thoracic disease it takes the form of intercostal neuritis. In thoracic lumbar disease of bird pains or epistemic pain. The reference in disease of the lumbar spine is to the hips and legs.

2. Night Cries are less frequent in spinal disease than in tuberculosis of the larger joints, but do occasionally occur in disease of the cervical or thoracic vertebrae. They are reliable evidence of the activity of the tuberculous process.

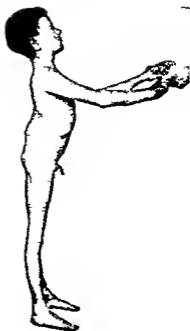
3. Paraplegia. The pathological explanation of the various forms of paralysis has already been discussed in some detail. It remains to consider the associated clinical features.

The paralysis may manifest itself early or late in the course of the disease. It may even arise after apparent cure. In any event it is important to search for its earliest evidences since the prognosis may be noticeably altered by appropriate treatment.

Whether early or late the paraplegic symptoms develop gradually. If the child has been able to go about, he may notice some stiffness



(a)



(b)



(c)



(d)

FIG. 112.—Tuberculosis of the δ_1 vertebra.

- (a) Disease of the lumbar region, with kyphus formation.
 (b) The same case at a later stage of treatment.
 (c) The disease is now healed and the presence of the deformity has been balanced by the compensatory curves below and above.
 (d) Forward flexion is performed with ease and freedom from pain, although there is still a remnant of the disease in the presence of a gibbus.

and tiredness or may show a fresh tendency to stumble or trip. There is difficulty in mounting stairs. These symptoms are all the result of muscular spasticity, sensory changes if they occur do so only a considerable time after the appearance of the motor phenomena.

4 Abscess Formation The situation of abscesses in connection with disease in the various segments of the spine has been previously described, the investigation of these sites is an essential part of the investigation of any case of spinal caries but the presence of certain symptoms will attract particular attention to the possibility of abscess formation.

The retropharyngeal abscess of cervical disease is associated with dysphagia and dyspnoea abscesses in disease of the upper thoracic vertebrae are usually anterior, and may therefore involve the recurrent laryngeal nerves and give rise to dyspnoea and vocal changes.

In the lumbar spine, the debris seeks the surface usually as a psoas abscess and the presence of infective material is so apt to induce irritation and spasm of the muscle, that there is often persistent flexion and lateral rotation of the limb, any attempt to overcome these deformities being attended with great pain.

THE PHYSICAL EXAMINATION

A 'routine' method of examination should be employed in investigating all cases of spinal tuberculosis. This should take note of the patient's general appearance, standing attitude, and gait, and must include a minute examination of the spine and pelvis. An X-ray examination is essential in every case.

1 The General Appearance A systematic general examination may demonstrate the presence of other signs of tuberculous infection. In general the body nutrition is poor.

2 Attitude and Gait There is often a strained and expectant facial expression for the child is in continual dread of any sudden jar or movement. When the disease is active no matter the situation, the patient walks with the leg joints semi-flexed to lessen the jar of sudden movements. In addition disease in each situation is associated with a characteristic gait or attitude.

In upper cervical disease, the position of the head is similar to that in a very neck, but the face is not rotated. In lower cervical disease, the head is thrown backwards, and to one side.

In upper thoracic disease the shoulders are raised and the arms and shoulders drawn backwards. The head appears sunken owing to the apparent shortening of the neck and the attitude is aptly referred to as the 'military attitude'.

In mid thoracic disease, the antero-posterior diameter of the chest is considerably increased, and owing to the shortening in stature the patient appears stunted and the arms seem unduly long.

In low thoracic and upper lumbar disease the thorax and head are thrown backwards, the abdomen is prominent the patient walks with the legs far apart and waddles—the so called "allerman's" gait. In lower lumbar disease there is pronounced lordosis and the chest

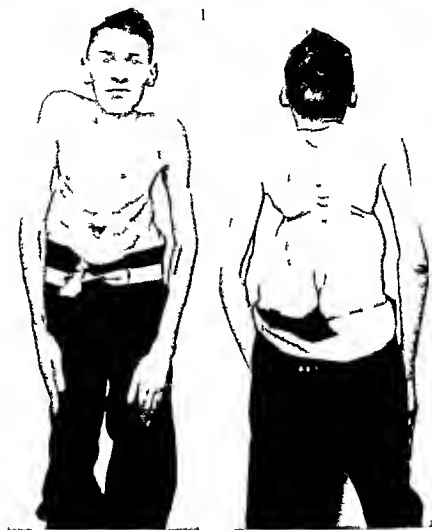


FIG. 113.—Tuberculosis of the Spine.
Late disease in the lumbar region.

is thrown forwards till the last rib and the iliac crest may be actually in contact.

3 Irregularities of the Spine The patient is stripped to expose the whole spine. Inspection may then reveal the presence of angulation deformity, lateral deviation, lordosis, flattening, or bowing or paravertebral swelling.

(d) Angulation of the Spine (Kyphosis) This is the most common sign it is the result of the collapse of the affected vertebra or vertebrae and varies in degree with the extent of the disease. When a series of vertebrae are affected the projection is slight and gradual but when only one body is diseased the angulation is localized and prominent. The anterior type of disease which affects a long segment of the column is associated with a long gradual curvature similar to that of the ordinary round shoulders.

(e) Scoliosis Lateral deviation often complicates kyphosis indeed the case may be mistaken for one of simple scoliosis.

(f) Boarding The normal anterior-posterior curves may be obliterated even though the vertical axis of the spine is straight. Such boarding or flattening is the result of muscular rigidity, and as it is one of the earliest clinical signs to appear its recognition is of great importance.



FIG. 113.—Tuberculosis of the spine. In the presence of thoracic disease a coin is picked up from the floor in this way.



FIG. 114.—Tuberculosis of the spine. The typical attitude of disease in the cervical region. The head requires support.

(g) Lordosis The spines above and below the site of the disease may show exaggerated forward curvature to compensate for the kyphosis.

(h) Paravertebral Thickening The width of the column at the site of the disease may be increased or a collar abscess may be seen pointing at one or other side. Such thickening is better distinguished by palpation the finger being drawn down the back on either side of the spinous processes.

The exact extent of the deformity should be recorded in permanent fashion, this is best done by means of good photographs, taken from the back and from the side of the patient.

4. The Movements of the Spine The natural efforts to protect the diseased vertebra result in a specific contraction of muscles which effectively

limits the spinal movements. This muscular rigidity is the most characteristic sign of Pott's disease. To check it the antero-posterior, lateral and rotatory movements of the spine are carefully tested.

Cervical Region Flexion, extension and lateral movements are limited in tuberculosis of any part of the cervical spine. rotation is also limited when the atlanto-axial joint is implicated.

Thoracic Region All movements are limited, but particularly that of flexion and the normal thoracic curvature is replaced by an area of flattening. When the patient is asked to pick up some object from the floor he does so by flexing the leg joints to lower himself and by



FIG. 110. An Unhealed Case of Thoracic Disease



FIG. 11.—Tuberculosis of the Spine

The deformity of the region of the thoracic vertebrae is due to the disease of the spine.

by keeping one hand on his knee to support the back and to avoid the unpleasant consequences of a sudden jar. In assuming the upright posture he slowly rises the supporting hand or hands being gradually advanced up the thigh—the so-called climbing up his legs manoeuvre.

Lumbar Region The normal lordosis is obliterated and the sacrospinalis shows marked boarding.

5 Examination for Cold Abscess All possible abscess sites should be explored. These are the pharynx, the triangles of the neck, the loins, the iliac fossa, the groins, the gluteal and the ischio-rectal regions. Sometimes the abscess is recognized only on X-ray examination.

6 Paralysis The paralysis is spastic with occasional involvement of the bladder and rectum only very rarely are sensory disturbances present. The paralysis may be incomplete or may at first be complete or become incomplete later. Its extent and nature depend on the level and the amount of cord involvement.

When the infection is in the cervical region the phrenic accessory and hypoglossal nerves may be affected. The arms are unaffected before the legs.

In thoracic disease there is spastic paralysis of the legs, without involvement of the sphincters.

In low thoracic and lumbar cases the lower limbs are paraplegic and the sphincters sometimes paralyzed as well. There are trophic disturbances and often bed sores.

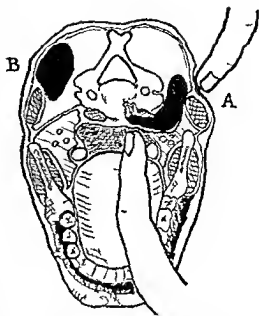


FIG. 118 — Abscess from Tub. rel. of the Cervical Region.

It is as the patient lies in a position through the (4) directing to the rectum as well as in a position to the angular abscess (B). (After Collet.)



FIG. 119 — Tuberculosis of the Spine. A tuberculous abscess has escaped from the joint under the scapular apophysis.



FIG. 120 — Tuberculosis of the Spine. A tuberculous abscess has tracked down from the joint and appears in the region of the great trochanter.

The legs atrophy and remain cold and lifeless. The motor paresis results in awkward jerking movements in the arm and stumbling and dragging of the toes, sensory changes are rare but there may be pain in the body or limbs and derangements of cutaneous sensation. The deep reflexes are exaggerated in the early stages but disappear progressively as cord degeneration proceeds.

7 Changes in the Thorax and Pelvis The chest shows a variable degree of alteration. When there is a high thoracic gibbus the chest is flattened and the sternum slopes downwards and forwards while the ribs have an increased downward inclination.

In low thoracic disease the chest is barrel-shaped while in lumbar cases the whole chest is displaced forwards and downwards the last rib often being in contact with the iliac crest.

These errors in configuration are readily appreciated on inspection.

8 Changes in the Heart and Great Vessels The position and size of the heart are often changed especially in disease of the upper thoracic spines.

The kyphosis results in some displacement of the heart the base being forced downwards and the apex tilted to a higher level. The myocardium may be hypertrophied since the great vessels are often kinked or posited the deformity. These changes are detected by the usual clinical methods.

9 Radiographic Examination

The examination is completed by an X-ray investigation both an antero-posterior and a lateral-view of the spine being taken. The diagnosis is thus confirmed the degree and extent of the disease estimated the presence of a cold abscess detected and any evidence of healing determined.

The lateral view is particularly valuable as it shows evidences of the disease long before the other. Jones states that irregularity at the anterior edge or corner of the vertebra is characteristic of early tuberculosis. Doubt and Bidgely believe that narrowing of the intervertebral disc is the earliest and most constant X-ray sign in tuberculosis of the spine. Later as the spine becomes buckled, the ver-



FIG. 11.—Tuberculosis of the Spine.
The unusual scoliosis is the surface through the lumbar triangle.

tebral body becomes wedge shaped. In addition during the active stage the affected vertebrae are less dense and decalcification has occurred and there is a want of clarity in the detail of the bones. As healing takes place the decalcification becomes less marked. Ultimately the diseased vertebrae form a continuous mass, the intervertebral spaces having disappeared and the adjacent bodies fused.



FIG. 1.—Tubercles of the Spine.

The tubercles of the spine are shown in the illustration above, showing fusion of the bodies and great deformity.

1. Summary of the Clinical Features of Tuberculosis in Special Regions

(a) Cervical Region

- (i) Limitation of head and neck movements from muscle spasm.
- (ii) Pain over the affected vertebrae aggravated by pressure on the top of the head and referred to the back of the head and the course of the cervical nerves.



FIG 123—Tuberculosis of the Spine
Active disease in the fifth and sixth cervical vertebrae



FIG 124—Tuberculosis of the Spine
The disease in the cervical region in process of healing

- (c) Deformity resembling wry neck with the normal cervical concavity or lordosis obliterated
- (d) The head is usually supported by the patient's hands
- (e) Abscess in the retropharyngeal or suboccipital regions
- (f) In cases with cord pressure paralysis of the arms before the legs ①
- (g) Occasionally sudden death from dislocation



FIG. 15—Tuberculosis of the Spine
The disease affects the upper lumbar region with collapse of the upper vertebrae.



FIG. 16—Tuberculosis of the Spine
The physical cause of the thoracic deformity of the first and second lumbar vertebrae.

(ii) Lower Cervical and Upper Thoracic Regions

- (1) Marked rigidity with angular kyphosis
- (2) Pain along the branches of the cervical or brachial plexus
- (3) Abscess in the retropharyngeal or supraclavicular regions or in the mediastinum
- ✓(4) Cord symptoms less common if right arm first affected

- (e) Occasionally, dilatation of the pupil from pressure on the sympathetic
- (f) Occasionally cough vomiting and slow pulse from pressure on the recurrent laryngeal nerves and vagus
- (g) Head and body turned simultaneously when patient looks to the side
- (h) Grunting breathing from pressure on the intercostal nerves



FIG 1 —Tuberculosis of the Spine
Dumb-bell abscess in the lower thoracic region.



FIG 1 S—Tuberculosis of the Spine
A dumb-bell abscess arising from disease of the seventh and eighth thoracic vertebrae.

(iii) Thoracic and Thoraco-lumbar Disease

- (a) Angular gibbus and muscular rigidity
- (b) Often palpable thickening of spine
- (c) Girdle pain, or pain over affected spines
- (d) Pain radiating to lateral aspects of the thighs
- (e) Ilia, or psoas abscess

(iv) *Lumbo sacral Disease*

- (a) Deformity slight
- (b) Vertebral thickening
- (c) Funnel shaped deformity of pelvis
- (d) Neuritis and referred pain as in lumbar disease (2)
- (e) Often flexion and pseudo rigidity of the hips
- (f) Psoas abscess



FIG. 1.3—Tuberculosis of the spine

Extensive disease of the 12th and 13th thoracic vertebrae which by collapse have merged into one mass. Calcification has taken place in the cold abscess cavity. The disease is now healed.

DIAGNOSIS

The recognition of spinal curvatures is not difficult when a well marked kyphosis is present but if the results of treatment are to be at all satisfactory a diagnosis must be made at a substantially earlier stage. Further, the presence of a gibbus is not invariable, even in late spinal tuberculosis with paraplegia the 'hump' may be absent. The important findings which establish the diagnosis are rigidity, pain, slight spasticity, abscess formation, and the radiological appearances previously discussed.

DIFFERENTIAL DIAGNOSIS OF POTT'S DISEASE

The early diagnosis may be anything but an easy matter, tuberculosis may be mistaken for a variety of conditions. In this connection it will simplify matters if the differential diagnosis is considered on a regional basis.

Cervical Pott's Disease Cervical caries may be confused with

(i) Congenital Torticollis This to some extent resembles Pott's disease in the abnormal position of the head and neck but in torticollis movement is painless and the shortened sternomastoid is very obvious. The face also is rotated towards the opposite shoulder, and is small and atrophied on one side, while the cervical spine itself is quite flexible. In that acute form of torticollis which is secondary to arthritis of the cervical spine there is a more acute history than in Pott's disease while there is usually a co-existing inflammatory lesion elsewhere e.g. tonsillitis. The condition also, as a rule subsides rapidly under appropriate treatment.

(ii) Developmental Abnormality A deformity is sometimes seen without signs or symptoms. An X ray may show fusion of vertebrae or absence of one half. There is no decalcification but such conditions are apt to give symptoms in later life from mechanical strain.

(iii) Sarcoma Sarcoma is accompanied by severe local pain, often by paralysis and by a certain degree of deformity, it is however, rare in childhood. The distinctive features are the severity of the symptoms, sensory changes, the presence of a palpable tumour, and early and progressive paralysis. The X ray picture is usually diagnostic.

Tuberculous Disease of the Thoracic Vertebrae Thoracic Pott's disease must be distinguished from

(i) Rickets Kyphosis may arise as a sequel to rickets but there are usually evidences of the disease in other regions. The kyphosis itself can usually be corrected without difficulty, muscular spasm is absent and pain is an unusual feature.

(ii) Scoliosis In scoliosis the spinal deformity takes the form of a lateral curvature and pain and muscular rigidity are absent. Inevitable and constant changes take place in the shape and direction of the ribs, these are readily apparent on inspection. In early cases, an X ray picture may serve to establish the diagnosis.

(iii) Osteochondritis This is a rare condition also called Calvé's disease, and of the same nature as Perthes disease. It is the result of an aseptic necrosis and shows a flattening of the vertebral body without involvement of the disc.

(iv) Schmorl's disease This is the result of a defect in the upper or lower growth plates of the vertebral body so that the disc herniates through them into the body of the vertebra. Localized lacharhe may be present but there is no deformity and the X ray distinguishes the condition.

(v) Kummell's disease This is a late, or an unrecognized manifestation of a crush fracture of a vertebral body. It is diagnosed from the history of injury and the fact that the disc, though somewhat distorted and narrowed is still present. It occurs in the dorso-lumbar region.

(vi) Aneurism This serious condition may produce in the thoracic region localized spinal pain and anterior erosion of the vertebrae, simulating an anterior parosteal type of tubercle. The erosion is however, clear cut and regular without involvement of the discs and without decalcification.

(vii) Scheuerman's disease, or vertebral epiphysitis In this condition an ill-defined pain in the back is present in the lower thoracic region of a child of about 12 years of age. A radiogram shows an irregularity of the epiphyseal disc most marked at the anterior edge of the body. The clarity of the intervertebral disc is lost and there may be some wedging of the vertebrae.

Lumbar Disease Tuberculosis of the lumbar vertebrae may be mistaken for

(i) Hip-Joint Disease In this condition there is usually a hump, from contraction of the psoas muscle. the joint also is kept in a flexed position. Symptoms directly referable to the spinal column are unusual, movement at the joint is painful and its range limited in all directions.

(ii) Sacro-iliac Disease This is rare in childhood. The pain and tenderness are situated directly over the joint. Spinal movements are unrestricted but flexion of the thigh with the knee extended is abruptly arrested by pain in the sacro-iliac region.

(iii) Low Back Strain Here the symptoms arise suddenly after injury, and the spinal movements are restricted and painful. Tender-ness can usually be elicited at the point of injury and one or other of the sacro-spinales may be in spasm. Radiological examination is negative and the limitation of spinal movements obviously voluntary and due to pain. The condition is relieved by rest.

(iv) Secondary Carcinoma This is distinguished from its occurrence—over 10 by a greater degree of pain by a total collapse rather than an erosion and by the absence of involvement of the disc. A primary growth is of course present but may not always be discovered.

(v) Pyogenic Disease This may be primary or part of a general infection. The pedicles and laminae are just as often involved as the body. The diagnosis from tubercle is made from the history, sudden onset, high fever, leucocytosis and acute pain.

(vi) Spondylitis Ankylopoetica This ankylosing disease of the spine occurs between 18 and 25 years of age and usually starts in the lower part of the spine, often in the sacro-iliac joints. It begins with pain and rigidity, and in the early stages is difficult to distinguish from tubercle although an X-ray of the sacro-iliac joints should identify the disease.

(vii) Osteoarthritis In the elderly this is a common cause of pain

in the lumbar region and often with a scutic radiation. It is easily diagnosed by an X ray which shows sclerosis and osteo-genetic reaction rather than decalcification and erosion.

PROGNOSIS

Vertebral tuberculosis is always a serious condition. In children the mortality is considerable but in adults there is even greater threat to life and a correspondingly higher death rate. Girdlestone's results are interesting. Of 176 cases treated by conservative means and by operation 52 per cent were well 7 per cent unsatisfactory and 14 per cent died. Of 94 cases treated by conservative means alone 47 per cent were well 6 per cent unsatisfactory and 23 per cent died. These reports are made at least five years after the termination of treatment. The remaining percentages were either incomplete or untraced.

The prognosis is greatly influenced by certain factors viz the stage of the disease at which treatment is begun, the efficiency of the treatment and the site of the lesion. In the last connection it may be said that tuberculosis of the thoracic vertebrae is the least favourable, since abscess is a common complication, paraplegia a frequent consequence, and the proximity of the thoracic structures a further danger.

When adequate treatment is applied early and for a prolonged period the outlook is greatly improved. Mortality figures in the sanatoria are low. The gibbus if recent will not only be arrested in its progress but will be effaced. Abscesses will be less frequent and paralysis rare and if it supervene will usually be cured.

TREATMENT OF TUBERCULOSIS OF THE SPINE

(A) GENERAL TREATMENT

Efficient general management is of the utmost importance in tuberculous disease of the spine. Indeed it is the actual curative factor in the treatment. It consists of the usual anti-tuberculous measures as for example improved hygiene healthy surroundings and a liberal nutritious diet. An open air regime is specially to be recommended, indeed these patients thrive best when out of doors from morning till night and in all weathers. Cod liver oil and tonics should be given freely.

(B) LOCAL TREATMENT

The local treatment is also important unless it is faithfully and efficiently carried out the general treatment is of little avail.

The object of the local management is to secure immobilization of the affected region of the spine, and in this way to give nature an opportunity to heal the condition. The exact details depend to some extent upon the conditions operative in each particular case—whether

it is uncomplicated, or whether there is a gibbus, an abscess or fistula or paralysis. Each of these different types of case must be considered, and treated on its merits.

The Treatment of an Uncomplicated Case

The majority of cases of Pott's disease may be placed in this category. The treatment is divided into stages—the first that of complete recumbency, the second, the stage of ambulation, and the third, the stage of convalescence. The treatment is carefully graduated, the patient passing by degrees from one stage to another, when symptoms pointing to activity or recrudescence of the disease are absent.

Nature, be it noted, in endeavouring to protect the carious vertebrae immobilizes the vertebral column by keeping the muscles contracted in involuntary spasm. In so doing, however, the spasm increases the tendency of the diseased vertebrae to collapse, and thus inaugurates or aggravates an angular deformity. The ideal method of treatment seeks to alleviate the spasm, to immobilize the spine, to prevent deformity, to arrest the progress of the disease, and finally to cure it.

Recumbency

Recumbency should be advocated at the start of treatment in all forms of the disease, and both before and after any operation. Some authors, however, have pointed out what they believe to be special indications.

These are

- (a) Acute symptoms.
- (b) Paralysis.
- (c) Psoas spasm or muscular contracture.
- (d) Lateral deviation of the spine.
- (e) Abscess formation.
- (f) When ambulatory treatment has been tried and found unsatisfactory.
- (g) When the presence of infection in the disease area precludes any attempt at operative treatment.

In my own opinion, once the diagnosis is made, recumbent treatment is absolutely vital.

Methods of Fixing the Spine in Recumbency

Fixation of the spine in the recumbent position in full extension affords more complete immobilization than any form of ambulatory fixation, and is therefore attended with greater and more rapid relief of symptoms. The necessity of rest in the recumbent position during the whole period of activity in Pott's disease, is not now seriously disputed, but the methods of achieving this rest are many and varied. Rest alone, however, is not enough to prevent the displacement of the vertebrae. Success can be obtained with certainty only by something which will retain the two segments of the diseased spine. I believe

that the treatment by plaster is the most efficacious the most simple and the most practical

✓(1) Treatment by Plaster Shell

Believing that effective fixation is an absolute necessity for the treatment of tuberculosis of the spine I give precedence to fixation in a properly made plaster shell. The other methods of splint frame, special bed, etc. in spite of their apparent simplicity, are when one reckons up everything much more complicated more difficult to apply and to look after and much less comfortable for children. The plaster shell is made for the individual case and is accordingly much more comfortable and fits more accurately

Plaster shells may be of two types posterior or anterior and in constructing them it is necessary to make the shell with the patient's body hyper extended as far as the activity of the disease allows

✓(a) Posterior Plaster Shell To make the shell the patient is placed face downwards on an ordinary operating table and the hyper extension is achieved by laying an arrangement of pillows under the upper part of the thorax and it may be under the pelvis. The body is covered with a single layer of white lint A series of broad plaster bandages is applied to the patient's back from head to foot the legs should be slightly abducted the knees flexed and the arms abducted to a right angle Laterally the plaster bandages should reach the anterior margin of the lateral aspect of the body. Where necessary, the case may be strengthened by incorporating aluminium strips. When the shell has set it is marked with a pencil to show where it may be trimmed and especially the area to be removed from the gluteal region for nursing purposes. It is now lifted off the patient's body and to do this it may be necessary to erase the edges off from the sides of the body. When completely set and dry the marked edges are cut off and the shell lined with thin felt. Straps and huckles are fixed to the shell in about four places—chest pelvis thigh and leg. These serve to retain a further degree of immobilization in the recalcitrant patient.

As patients who are being treated in a plaster shell should be turned over frequently to have their backs attended to, it is a useful plan to make a lid or anterior shell in which they can lie while receiving this attention. The anterior shell is placed in position and the two cases are strapped together and thus a complete plaster box is formed in which the patient is securely held. The box is now rolled over and the posterior shell lifted off. By this means the skin of the back can be exposed and treated with methylated spirit and boracic powder without interrupting the immobilization at all. The condition of the skin is of particular importance when methods of correcting the deformity are in use as the skin is then more subject to pressure necrosis. Where foot pieces are used, and they are only necessary in the posterior shell they are quite separate from the plaster case so that they do not form a fulcrum for the patient to lever himself up by pressing his feet against the foot supports. This would seriously detract from immobilization.

of the spine. Hence foot pieces of aluminum are slipped into the leg gutter of the plaster.

Although the treatment of Pott's disease by a plaster shell appears to be somewhat elaborate there is no real difficulty and its use need not be limited to a well equipped hospital. In the case of children of course the shell has to be repeatedly changed as the patient outgrows the preceding one.

(35) Anterior Plaster Shell This is a very comfortable method and the one of choice in treating low thoracic and lumbar disease and is applied with the patient lying on his back. The hyperextension is achieved by allowing his head and neck to drop to a lower level than the area of disease by an appropriate arrangement of small pillows. The plaster is made in the same way as the posterior one. It is found that defecation and micturition are performed in an even more cleanly manner than with a posterior shell. The anterior shell has the further advantage that when the child tries to look about him the tendency is for the spine to be hyperextended, whereas in the dorsal decubitus the tendency is towards flexion. The result, therefore, is that in the anterior shell there is less likelihood of the formation of a gibbus. The shell is mounted on a wooden frame and the head is supported on a box and pillows. The author believes that the anterior shell should be universally adopted unless there are contraindications to its use. These would appear to be a large abscess such as a psoas sinus which require dressing anteriorly, paraplegia or spasm. It is quite impossible to have a spastic patient in an interior shell, since the spasmodic movements quickly irritate sores on his knees.

This method is particularly useful for the nursing of cases after arthrodesing or other operations on the spine. The patient need only be turned on to a posterior shell once a week for cleaning purposes. The method is depicted in Fig. 131.

(36) The Whitman Frame

The Whitman frame is also a useful method for fixing the spine while the patient is recumbent but it has to be supplemented by special appliances when the disease is in the upper thoracic and cervical regions. The frame is a modification of that evolved by Bradford; it was designed to enable the deformity to be corrected to give more direct support to the patient and to interfere as little as possible with the clothing and the nursing. It consists of a rectangle of ordinary galvanized gas pipe or steel tubing of small diameter. A frame is made for each individual patient; it should be about 6 inches longer than the patient and about three fourths of his width, the lateral bars lying opposite the articular surfaces of the shoulder and hip joints. The frame is completed by the addition of a strong canvas cover which stretches between the lateral rods and is laced up the back. Rubber squares laid under the buttocks protect the canvas from being soiled. Two thick pads of felt are sewn to the part of the canvas which is going to support the diseased vertebra or

the gibbus, when present. These lie parallel to each other, and should be placed on either side of the spinous processes, they are usually about 7 inches long and 1 inch thick. Their function is to fix the part more firmly, and to guard the gibbus, or the spines of the diseased vertebræ when there is no deformity, from undue pressure. Wearing only an undershirt and stockings, the child is placed on the frame and fixed there by straps, or by an "apron" piece. The child should be comfortable on the frame, and clothing other than the undershirt should be made large enough to be easily applied over the frame, in order to avoid undue disturbance.

When necessary the shoulders may be fixed to the frame, and when the lower segments of the spine are involved, the legs may be restrained by applying a broad swathe round the thighs. When muscular spasm

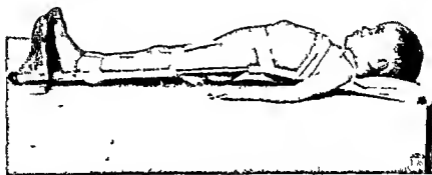


FIG. 130.—Tuberculosis of the Spine. A Whitman Frame in use in a case of Lumbar Disease.

The retention straps, foot piece, and the angling of the frame at the site of the disease are shown.

is a marked feature, traction may be applied quite simply by adding the necessary fittings to the original frame.

As soon as the child has become accustomed to the restraint, the frame may with benefit be further adjusted. Originally it was thought that the deformity could be made to disappear by gradually angling the frame opposite the gibbus. Since the shoulders and the pelvis are fixed, such angulation of the frame leads to hyperextension of the spine opposite the collapsed vertebræ, which thus tend to be "opened" out. Modern opinion is not agreed as to the desirability of this procedure, as the forcible separation of the collapsed vertebral surfaces is said to weaken the spine and delay healing.

The unsightly deformity can be disguised adequately, without endangering the healing process, by producing compensating curves above or below the gibbus. When the disease is below the tenth thoracic vertebra, the lordosis should be induced above the deformity, if the gibbus is above the level of the tenth thoracic, a lumbar lordosis should

be aimed at. For these purposes the frame is angled not at the site of the deformity but above or below it, according to the requirements of the individual case. That excellent æsthetic results may be obtained by this means is evident from Fig. 112—the photograph of a case so treated.

At regular intervals the child is laid face downwards and the frame removed. The back is then inspected, bathed with alcohol and powdered before the apparatus is re-applied.

The Whitman Frame is most suitable for children. It forms a moderately good method for treatment under private conditions rather than in hospital since the patient is perhaps a little easier to nurse provided there is someone who understands the position. The child may be lifted off and on the bed easily for toilet purposes. It is not however an ideal way of fixing the spine and is not to be compared with a plaster shell.

(iii) Thomas's Splint Method

The Thomas's double frame may also be employed as a method of immobilization during the recumbent state of spinal tuberculosis. It is easily applied, fairly clean and cool and the child is left unhindered by any bands or apparatus in front. The frame must be made anew for each individual, the method therefore is a somewhat expensive one. Despite



FIG. 111.—Tuberculosis of the Spine. Plaster shell.

It is shown in the patient's life to be the best method with tal trials and will stand well.

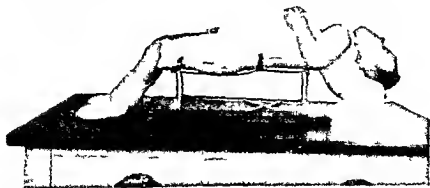


FIG. 112.—Tuberculosis of the Spine. The treatment of high Thomas's Disease by means of an angled plaster shell.

The position is retained by straps (not shown).

this it has certain advantages over plaster in that the putting is easier and the splint need rarely be removed. Abscesses tracking to the surface can be more efficiently observed, and heliotherapy can be more directly applied.

The frame is really a Thomas's double hip frame modified by the addition of a head piece. The child is laid on the frame with the head resting snugly in the head piece and the wings are moulded round the

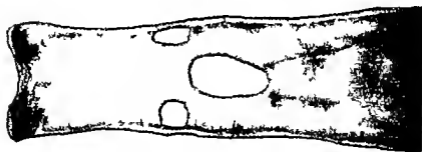
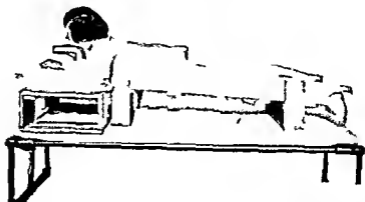


FIG. 133 Anterior Shell of plaster of Paris used in the post operative stages of *Hibbs' and Albee's operations*

A special wooden frame is used in conjunction with it

trunk and legs. The legs are bandaged to the frame and to prevent genu recurvatum pads are placed beneath each knee.

The rational treatment of spinal tuberculosis during the period of activity therefore consists of

(a) Recumbency

(b) Fixation either on a Whitman frame in a plaster shell or on a double Thomas's frame and

(c) Some form of hyperextension or traction such as that obtained in the first two of the methods of immobilization

This recumbent stage of treatment lasts from eighteen months to two years, after which it may be discarded provided certain requirements are fulfilled. These are

(1) that the patient is not suffering any pain either spontaneous, or elicited by pressure on the back,

(2) that the general condition is good and there is reason to believe that the tuberculous process has been arrested,

(3) that the kyphosis is not increasing

(4) that the temperature remains normal,

(5) that the weight is increasing.

(6) that the radiographic appearances are satisfactory

Should it be decided to discontinue recumbent treatment, the patient must be kept under close observation for some time after, since unfavourable symptoms may recur. He is usually kept in bed on a firm mattress but without retentive apparatus for a few months. Any return of pain, the appearance of paralysis, deterioration in general condition, the development of abscesses, or increase in kyphosis, imperatively demands the resumption of recumbent treatment.

Ambulatory Treatment.

When the child is finally allowed upon his feet the spine must still be carefully protected and numerous methods have been devised towards this end. Usually a plaster of Paris jacket, or some form of brace such as that devised by Thomas is used, the writer mainly relies on the plaster jacket, as it has to be made for each patient, and therefore fits perfectly and is comfortable in addition to affording excellent support to the spine. It has the further ad-



FIG. 114

FIG. 115

FIG. 114.—Tuberculosis of the Spine. A plaster cast for high Thierie disease.

A wind wheel over the child is to prevent undue pressure on the "bustle" over the cast for a long period of time.

FIG. 115.—Tuberculosis of the Cervical Spine. Plaster jacket with fillet support.

The essential in this case of the plaster and the child as that window are shown.

vantage that it cannot be removed without the knowledge of the surgeon

Application of the Plaster Jacket. The plaster bandages may be applied with the patient in the erect position but are more usually applied by the sectional method as previously described. In this way the jacket can be more accurately moulded to the various prominences and depressions of the trunk. If applied in the erect position it is desirable to relieve the diseased vertebrae of any superincumbent weight and this is most easily done by suspending him by means of a cotton sling passed under the chin and below the occiput



FIG 136 Tuberculosis of the Cervical Spine. A celluloid collar used in the later treatment of the disease

A thin vest may be worn alone or with the bony prominences further protected by felt pads. The undervest should be thickly impregnated with boracic acid to diminish the risk of verminous infestation which often makes the life of the poorer class of patient wellnigh intolerable.

The plaster should be applied closely, sores are much more liable to develop in loosely fitting plasters, indeed the majority of so called pressure sores are in actual fact friction sores. In addition a loose fitting jacket deprives the spine of much of its support. As each bandage is applied therefore it is carefully moulded over the bony points and especial attention is paid to the pelvis where all the weight is borne. After the plaster has set, the edges are trimmed and segments of appropriate size cut out one over the front of the abdomen, to

allow for any abdominal distension and one over the iliacs to prevent undue pressure. The plaster must be thoroughly dry before the patient is allowed out as the chilling effect of a damp jacket may have serious consequences.

Calot uses a somewhat similar jacket during the recumbent stage, but in addition to the anterior window he cuts a vertical trap door over the gibbus. Under the edges of this posterior opening he packs pieces of felt which exert a certain amount of corrective pressure on the kyphus.

When the disease is situated in the higher thoracic vertebrae the jacket should reach well above the affected bones. In cervical cases

the support is usually of the 'Minerva' type the plaster extending upwards as far as the jaw, chest and occiput. Alternatively a 'fillet' support may be employed in this jacket the head is kept extended by carrying a band of plaster round the forehead while in front the plaster does not reach so high. Colts' grid jacket may also be used. This jacket leaves the throat, jaw and face free, but is moulded up over and round the head and down to include the forehead.

Whichever type of jacket is advocated it should be worn for at least eighteen months it is then discarded in favour of a removable celluloid jacket.

The Celluloid Spinal Jacket The celluloid spinal jacket is fashioned over a cast or mould of the patient's spine. The cast is made by applying and accurately moulding a series of plaster of Paris bandages to the trunk to form a light plaster shell. When hard the shell is bivalved and removed and the two halves later joined. The reconstituted shell is now filled with plaster cream which hardens to form an exact replica of the patient's torso. Successive layers of modified cheese cloth or muslin are applied in single layers to the cast each layer being brushed over with a solution of celluloid in acetone. About twenty layers are necessary to make a strong jacket. When completed a series of holes is made in the jacket for ventilation purposes the edges are then bound and the necessary straps and buckles fixed.

It forms a very light and strong support in addition it is fairly cheap to make, easily kept clean and can be quickly removed. It is usually worn over a light undervest and since it is quite comfortable it need not be removed at night.

Convalescent Stage

It cannot be too strongly urged that spinal tuberculosis is a slow and extremely chronic disease. For this reason treatment to be



(a)

(b)

FIG. 137.—Tuberculosis of the Spine. Celluloid Jackets used in (a) low and (b) high thoracic disease.



FIG 138 Tuberculosis of the Spine A well moulded Celluloid Jacket for use in the Convalescence of Lumbar Disease

tant to realize that the decision rests on something more convincing than on the period of time which has elapsed

During the recumbent and ambulatory stages radio-graph examinations should be made at frequent intervals. So long as there is any cavitation any unevenness in the bone shadow or evidence of decalcification it may be concluded that the disease is not yet healed. When the lime content has been restored to normal when pain and muscular spasm have been entirely abolished and when the general condition is good the possibility of convalescence may be considered

The Convalescent Regime This should extend over a period of about two years it is better to continue treatment for two years too long than

effective and reasonably certain must be prolonged over a considerable period and convalescence should not be hurriedly begun. Furthermore each patient must be supervised carefully during convalescence lest any recrudescence of the disease occur. Calot has stressed the desirability of erring by excess rather than by default, of precautions and this is indeed true.

The convalescent treatment of vertebral caries begins when consolidation of the collapsed bodies is complete this is usually three or four years after the start of treatment but again it is impor



FIG 139—Tuberculosis of the Spine A Celluloid Jacket used in a case of Lumbar Disease in the late convalescence.

The following anterior extension posture may unduly stiffen the flexor (Sandoz as fig 112.)

for two months too short. At first the apparatus is removed only for a short period each day, and then reappplied, gradually the intervals of freedom are increased until ultimately the support can be dispensed with altogether.

Should there be any return of pain or any increase in the degree of the deformity the support is immediately replaced and its use continued for a further prolonged period.

RECUMBENT TREATMENT AS APPLIED TO INDIVIDUAL REGIONS

Each segment of the vertebral column has its individual peculiarities of structure and function in spinal cases therefore there are special difficulties to be overcome in each region and special complications to be anticipated and prevented. For this reason the recumbent treatment may require to be modified or supplemented according to the vertebral area involved.

The Cervical and Upper Thoracic Regions As the cervical vertebrae are of small size and compact structure the disease is usually



11-140—Tuberculosis of the Spine. The treatment of Cervical Disease by means of box and traction.

The head is held in a box at the top of the bed. It can be swung forward and backward held in position by rubber bands to allow reading, without strain of the eyes or the neck.

limited in extent. The prognosis as regards recovery from the disease is good, and there is usually little or no apparent deformity since the great mobility of the cervical spine compensates considerably for any local fixation.

Some method of extension should be used during the recumbent stage, and this is best carried out by weight traction. A leather strap is passed round the forehead and occiput, with a chain strap attached, and the whole apparatus is connected with a weight and pulley over the head of the bed, the usual weight required is two or three pounds. Should any lateral support be necessary, it may be supplied by means of a box enclosing the head and neck, in this case the straps pass to the pulley through the bottom of the box. Hyperextension is also easily obtained by placing a U shaped pillow behind the nape of the neck.

Traction and recumbency are continued in this way for about nine months, the extension may then be released, but the cervical spine should be immobilized for a further nine months between sand bags. When the tuberculous disease is actually situated in the occipito-atlantoid region a similar method of treatment is employed, but here the prognosis is not so good, since the disease is in close proximity to the vital medullary centres. Sudden death may occur from compression of the spinal cord, and abscess formation is a common and dangerous complication.

Where the disease is situated in the lower cervical region or in the upper thoracic region a useful method is by means of a posterior shell with hyperextension, as is depicted in Fig 132. Straps are used to fix the head down in the capital socket of the plaster. After the necessary period of recumbency a plaster jacket of the "fillet" support type as shown in Fig 135, may be used, and in the later stages of the disease a celluloid collar, such as is seen in Fig 136.

The Thoraco-lumbar Region. It is difficult either to prevent or to cure deformity resulting from disease of the upper thoracic vertebrae hence round shoulders and a short neck are frequent sequelae. Paralysis not infrequently occurs, and when it does immobilization must be complete. In thoracic disease the fixation may sometimes be secured in children, by means of a Whitman frame, but for the majority of cases some form of plaster case, and preferably an anterior shell, is the best form of apparatus, the shell restricts the movements of the shoulder, and therefore of the affected vertebrae also rather more efficiently. Recumbent treatment should be continued for from eighteen to twenty four months.

⊙ In the lumbar region the prognosis is good. Healing takes place quickly and the trunk is left only a little shorter and broader than before, though a peculiar erectness of attitude may persist. Here, too, the preferred method of treatment is by the anterior plaster shell for it has the additional advantage of preventing the contraction of the psoas muscle which is so common and which may result in grotesque deformity. This contraction is usually evidence of an abscess at the origin or within the substance of the muscle, and during the active stage of the disease is attended with pain. If however, the abscess is of considerable dimensions it may prevent the use of the anterior shell and a posterior one may have to be substituted for it. In early

cases the psoas contraction yields to sustained traction but in old neglected contractures the shortened tissues may have to be divided by open incision, and the deformity thereafter corrected by forcible manipulation

In uncomplicated cases, recumbent treatment should be continued for sixteen to eighteen months when there is an abscess or when psoas spasm is present the period of recumbency should be prolonged

TREATMENT OF THE COMPLICATIONS OF POTT'S DISEASE

The Abscess In most cases of Pott's disease an abscess is present at one time or another but unless it is associated with pressure symptoms or appears as a palpable tumour its occurrence can only be presumed. It is more common in connection with disease in the lower parts of the spine, where the size of the vertebra is relatively large

The abscess consists of a central mass of caseous debris, with a limiting wall of granulation tissue. The contents are often entirely liquefied, the fluid is then of a creamy colour with pieces of cheese like material floating in it. In the absence of secondary infection, the fluid is sterile

At any stage an abscess may become stationary, and later be absorbed. Occasionally it appears early and grows rapidly in which case the disease is usually an acutely destructive one

The more usual history is that the swelling slowly increases in size, and under the influence of tension and gravity follows the line of least resistance towards the surface of the body. Its course may thus be directed by fascial planes, muscle sheaths nerves or vessels. The treatment of abscess by injection is fully considered in the chapter on Tuberculosis of Joints

Active Treatment of Abscess in Various Situations

Cervical Region Abscesses in connection with cervical disease usually become evident in the retropharyngeal space, and, to avoid their pointing and rupturing into the septic pharynx, they should be evacuated from the neck. Two methods are available

(1) The abscess may be aspirated through a needle inserted behind the posterior border of the sterno mastoid. This is the better method, provided the contents are not too thick to be drawn through the aspirator

(2) Should aspiration not be feasible for any reason the abscess must be evacuated by open operation. A vertical incision is made behind the sterno mastoid muscle, care being taken to avoid the accessory nerve. The transverse processes of the vertebrae are exposed between the sterno mastoid and the splenius capitis and levator scapulae muscle, the abscess is located by following the anterior surface of the processes. After the cavity has been cleansed with pledgets of gauze, the incision is completely closed. Abscesses from middle cer-

vical disease usually point in the supraclavicular region and there is no difficulty in their treatment by aspiration.

Thoracic Region Abscesses from thoracic disease rarely call for operative interference though occasionally they may press on the respiratory tract and give rise to dyspnoea of a spasmodic or asthmatical nature. If this spasmodic dyspnoea is frequent and severe it may be wise to evacuate the abscess contents by costo transvers ectomy.

Costo-Transversectomy *Operative Technique* The operation is performed on the left side. A transverse incision, 7 cm in length is made over the vertebral end of the rib corresponding to the apex of the gibbus. The rib is exposed and the periosteum carefully elevated on the superficial and deep surfaces. The rib is then divided with nibbling forceps 4 cm from the tip of the transverse process of the corresponding vertebra. The transverse process is cut through at its base and removed after its costal attachment has been divided. The medial end of the rib is now lying in a perosteal tube attached only by its head, and it is removed by combined twisting and traction. Occasionally the removal of the rib opens the abscess cavity but if it does not the tunnel should be explored gently with the finger and when the wall of the abscess is located it is incised with a blunt instrument. Where more than one rib is resected the neurovascular bundle between the two is encircled with a double ligature, tied in two places, and divided.

Occasionally also when more than one rib is removed a longitudinal incision in the line of the costo transverse joints may be employed with advantage.

Costo transversectomy has certain advantages. It attacks the main cause of the paraplegia. The abscess cavity, and by emptying the abscess reduces the pressure on the cord and the toxicity of the focus. (4) Drainage of the material after costo transversectomy is away from the cord—not around it as after laminectomy. (5) The operation does not weaken the bony spine. (6) The technique is not difficult, nor is there any great operative risk. A relatively large canal is formed through which it is possible to evacuate not only fluid pus but granulation tissue bone sand and caseous material. Any further collection of pus that may form after costo-transversectomy will come to the surface at the site of operation.

Lumbar Region Abscesses in the lumbar and iliac regions are deeply situated and rarely call for specific treatment indeed 70 per cent are spontaneously absorbed. If they become superficial they are aspirated.

In the event of their becoming secondarily infected evidences of toxic absorption may arise in that case the gravity of the case is greatly increased and the abscess must be opened forthwith. A vertical incision is made along the lateral border of the sacrospinalis,

between the 1st rib and the crest of the ilium. The dense fascia is divided, to expose the quadratus lumborum. The muscle is split longitudinally to the lateral side of the transverse processes, the lumbar arteries being carefully avoided. The contents are evacuated and the cavity drained.

The Paralysis

The occurrence of paralysis is evidence of the activity of the disease, and absolute recumbency must be ensured immediately along with fixation and traction or hyperextension. In early and mild cases, especially in children, this is sufficient, but in adults operation must be seriously considered. Mme Sorell does not advocate operation; she finds that, in early cases, the large majority are relieved by conservative measures, whereas in a majority of the late cases the condition persists even after operation.

Girdlestone, on the other hand, wholeheartedly advocates operation in paraplegic adults, whether the paralysis appears early or late. He aims at relieving the cord compression, by costo transversectomy, by laminectomy or by both, and in addition, performs a twin graft fixation. Costo transversectomy is carried out particularly when a spherical or nearly spherical prevertebral abscess is shown in the X-ray film, for this appearance suggests that a collection of debris is being held up under considerable tension by the prevertebral fascia, and, since it has been unable to escape upwards or downwards, has tricked backwards and compressed the cord.

Jones and Lovett recommend operation when the paralysis is of long duration and especially when sensory symptoms are present. Whitman insists on eighteen months conservative treatment before operative interference is considered.

The choice of operation lies between

- ✓ Costo transversectomy, to evacuate the abscess
- ✓ Laminotomy, to enlarge the canal and give the cord more space
- ✓ Laminectomy

After the laminectomy, Girdlestone inserts a graft to bridge the opening and compensate for the loss of bone tissue.

✓ Laminotomy (Fraser) A vertical incision is made over the spinous processes with its centre opposite the area of disease. The muscles and soft tissues are reflected to either side, leaving the posterior surfaces of the lamina exposed, over an area extending from one vertebra above to one below the lesion. Using Fraser's special laminotomy forceps the appropriate lamina is divided as close as possible to the transverse processes, the interspinous ligaments at the upper and lower limits of the laminar section being divided also. This detached spino-laminar segment is now displaced backwards to increase the space available within the spinal canal.

✓ Laminectomy and Bone-grafting (Girdlestone) The operation is carried out with the patient lying on a plaster shell. The incision is made slightly to the left of the midline to keep the scar

away from the spinous processes. The spines are now exposed, and an incision made over their apices, and carried by a dip of the knife from the spine through the interspinous ligaments over the required area. Two saw cuts are next made into each spinous process, these cuts pass forwards and slightly laterally to right and to left and lever two thick flakes of bone laterally from the lateral aspects of each spine. An osteotome is then used to separate these lateral flakes completely from the central portion, they are carried laterally along with the periosteum of the posterior surface of the laminae exposing the laminae completely, but only over the area in which the laminae are to be removed. A wide portion of each lamina is then excised, until sufficient bone has been removed to relieve all pressure. The spinal dura is not opened, but the debris is evacuated from the sides or the front

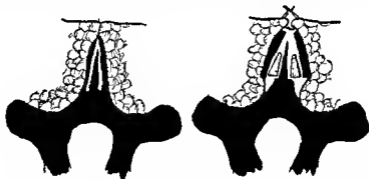


FIG. 141.—Tuberculosis of the Spine. Girdlestone's modification of Allcock's Arthrodesis of the Spine. (After Girdlestone)

of the theca. Two identical grafts—the so called 'twin' grafts—about three eighths of an inch wide are now cut from the tibia with an electric saw. These are laid one on either side of the central portion of the spine, with their periosteal surface deep, it may be necessary to make the grafts flexible by means of a series of transverse cuts if there is much angular curvature. When the graft has been placed in situ the edges of the supraspinous ligament, carrying with them the flakes previously detached from each spinous process, are sewn together over it. The patient remains on the plaster shell for three or four months.

In the presence of paralysis the greatest care is necessary to avoid the formation of bed sores, and the onset of troublesome contracture deformities. Massage is contra-indicated, however, as it is likely to irritate the affected nerve centres and augment the paralysis.

The Gibbus

To the patient, the most important feature of Pott's disease is undoubtedly the deformity, and, though the surgeon should recognize that it is only a symptom, a good deal of consideration should be given to the possibility of correcting it in view of the mental distress for which it is responsible. Ideally, the treatment of spinal tuberculosis

should seek to prevent the development of a gibbus but this ideal is difficult to realize. The reduction of an established kyphosis is difficult and should not be rashly undertaken. In this connection it may be stated that deformities of relatively short duration respond better to remedial measures while the most favourable situation is undoubtedly the middle segment of the spine—the middle and lower thoracic vertebrae—as there a greater amount of leverage can be exerted on the deformed vertebrae. Correction of the gibbus is really a misnomer, since we tend rather to hide or camouflage the deformity by making compensatory curves below and above it. To open out a curve formed by collapsed vertebrae might well reactivate the disease and would certainly delay it enormously since healing must be by coaptation of the neighbouring vertebrae.

Methods of Minimizing Angular Deformity

Only gradual methods can be considered sufficiently free from danger to warrant their employment. The rapid correction of tuberculous deformities under anesthesia stands utterly condemned.

The gradual methods in common use are

- (1) The Whitman Hyperextension Frame as described (p. 279)

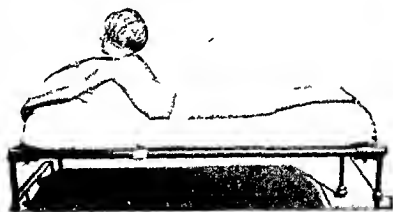


FIG. 142.—Tuberculosis of the Spine. The first stage in correction of a Low Thoracic or Lumbar kyphosis.

(2) Wedge Block Method. Good results can also be obtained by this simple method—the gibbus may be improved, and certainly compensatory curves can be produced above and below the kyphosis, which effectively mask the deformity in the event of its incomplete correction.

The patient lies prone, and a series of wedges are introduced to support the upper part of the trunk to the required extent (Fig. 142). The effect of the wedges can be enhanced by arranging a pad over the gibbus and pulling it against the kyphosis by tapes attached over the head of the bed, to weights. At the same time a counter pull can be applied to the spine above the level of the gibbus by traction strings which pass over the shoulders, and are attached to weights at

the lower end of the bed. The patient is kept in this position for the greater part of the day and the wedges supply a convenient means of leverage in straightening out the deformity. In old cases where the gibbus is rigid and there is no give, a considerable æsthetic improvement is obtained by the production of compensatory lordotic curves. This is well demonstrated in Fig. 112 where the posture of the body has been greatly improved despite the fact that the gibbus is still prominent.

The great risk of forcible corrective methods is the separation of partially healed opposing surfaces with consequent delay in cure. While it can be truly said that no method is absolutely immune from danger the evil potentialities are in the author's opinion reduced to a minimum in the above procedures.

Operative Treatment

It has for long been recognized that some form of internal splint which effectively controls or prohibits the movements of the spinal

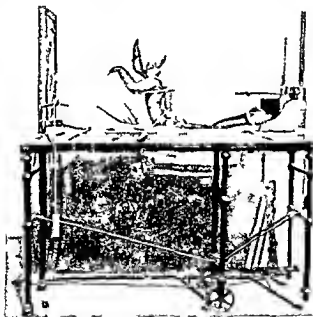


FIG. 143. Tuberculosis of the Spine. The second stage of Correction of a Kyphosis. The poles and wedge that is applied as well.

column would be a reasonable and rapid method of attacking Pott's disease. Indeed it may be said that the spine is ideally constructed and situated for the adoption of such procedures since the joints can be easily and completely arthrodosed without intruding on the actual area of disease—i.e. an ideal extra articular fixation can be carried out.

Yet spinal osteosynthesis has its detractors as well as its advocates. Calot has abandoned the method. He thinks that open operation in Pott's disease is definitely harmful rather than beneficial since in his

experience it carries with it an appreciable mortality and in no way shortens the period of convalescence

Sorrel supports operative methods of spinal fixation but points out that operation is not followed by increased vascularity, nor is any osteogenetic stimulant produced

Albee urges operation at all ages, but most authorities pursue a middle course and there is general agreement that osteosynthesizing methods should never be used in the active stage of the disease, but only when this has ceased and there is evidence of healing. It is unusual to operate in children though there may be cases with extreme loss of bone when a graft will support the spine and prevent gross deformity.

When the spondylitis is already on the way to healing or is already healed as a result of conservative measures the graft may contribute considerably to the stabilization of the defective spine and to the maintenance of the result already achieved. Following the necrotic process subluxations in the intervertebral joints certainly result from the dislocation of the body fragments. This, no doubt leads to seriously altered statics in the whole vertebral column and to manifestations of insufficiency of the muscular and ligamentous apparatus with pain. We must admit, however that the juvenile organism is able to adjust itself to even a very severe deformity over a very long period of time, although increasing manifestations of fatigue appear ultimately. These are often interpreted as indications of recurrence of the tuberculous inflammation, whereas they are as a matter of fact, merely signs of static insufficiency. In such cases operation does seem to be indicated, but it is directed towards the relief of symptoms and not against the disease itself. Freund believes that even before the onset of static insufficiency of the spine, the spinal fusion may be effective immediately after the conclusion of conservative treatment. It acts perhaps as a new stimulus, capable of forcing the organism into the last stage of healing, which is usually somewhat protracted and so of bringing about somewhat more rapidly bony union of the vertebral fragments. It may even serve as a local storehouse for lime from which the diseased vertebra may draw in the process of recalcification.

Indications and Contra-indications for Operation In Albee's opinion, the main indications for operation are

- ✓ Pain
- ✓ Muscle Spasm
- ✓ Increasing Deformity
- ✓ Abscess formation
- ✓ Paraplegia

Actually it is usually carried out when the activity of the disease has ceased and healing is in progress in cases where deformity might be expected in the absence of further support, and also to expedite healing and to make it more certain. It is most useful in the thoracic region as lumbar disease usually heals well without the assistance of internal grafts.

Operation is contra indicated where there is secondary infection with high fever. In all operations and especially where there is no gibbus to mark with certainty the site of disease it is advisable to have a localizing radiogram done by using a piece of metal over the supposed site and marking it with a scratch in the skin.

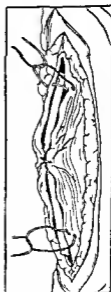
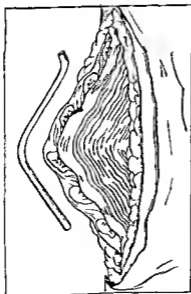
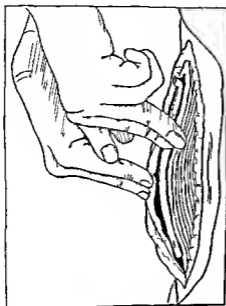


FIG. 144.—A series of diagrams to illustrate the stages of Albee's operation for tuberculosis of the lumbar vertebrae.

1. **Albee's Operation** It is Albee's technique that is most usually followed in performing the operation of spinal fixation. It is certainly attended with less shock and can be more quickly performed than

that of Hibbs, but the graft is comparatively rigid, and while to some extent it can be adapted to the curvature of the spine—by rendering it flexible by means of a series of transverse saw cuts—yet in the presence of marked angular deformity it is unsatisfactory.

The following details are taken from Albee's original description.

"Through a curved incision the spinous processes are exposed, the supraspinous and interspinous ligaments are divided longitudinally, and the spinous processes split in half nearly down to the neural arches, one half of each spinous process is fractured completely at its base

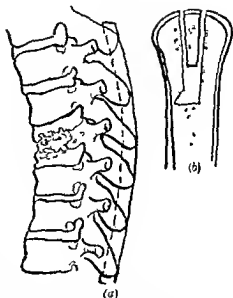


FIG. 145.—Tuberculosis of the Spine
Albee method of spinal fusion

(a) The graft in situ.
(b) The method of insertion.

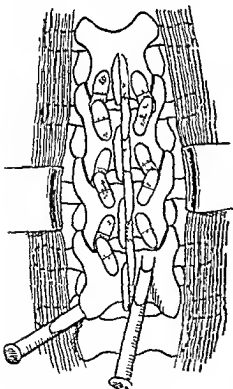


FIG. 146.—Hibbs Method of Arthrodesing the Spine

and displaced laterally. The graft bed thus prepared presents a median longitudinal gutter, into which a graft of sufficient length, which has been removed from the tibia by a motor saw, is placed. The graft may be curved to fit the gibbus by sawing a series of transverse cuts on its narrow side. The graft is immobilized by sutures of kangaroo tendon or catgut, and the supraspinous ligament, muscles and fascia are sutured over this. The graft should be sufficiently long to include at least two vertebra above and two below the site of the disease."

✓2. Hibbs' Operation. This operation has the advantage of materially decreasing the external deformity, and can be used regardless of the extent of the gibbus. It is also more likely to be followed by a strong peristaltic action with a sub-

sequent deposit of new bone, and ultimately by a greater degree of fusion

It aims at inducing ankylosis at five distinct points, viz the lamina and the articular process on each side, and the spinous process in the mid line

The following is an account of the operation

A longitudinal incision is made directly over the tips of the spinous processes, it passes through the skin, supraspinous ligament and the periosteum. The periosteum is split over both the upper and lower borders of the spines and laminae, and stripped back on either side to the base of the transverse process

The joints at the base of the transverse processes are now destroyed, by curetting their opposing cartilaginous surfaces. The adjacent edges of each lamina are now bared of periosteum and ligament, and, with a gouge, small portions are elevated and arranged to form substantial bony contact. The lower piece from the lamina above is turned downwards to make contact with the lamina below, while the upper flake from the lower is turned up to establish contact with the upper lamina

Each spinous process is now incompletely fractured at its base and turned down to come into apposition with the fresh bone of the spinous process immediately below. The entire sheath of periosteum and split supra spinous ligament is now brought together over the processes, sutured with strong catgut, and the subcutaneous tissues and skin approximated

3. Multiple Graft Method of Brittain This method is useful in the thoracic area, especially if there is much kyphosis, making the fitting of a single graft difficult. The grafts are cut from the anterior surface of the tibia by a series of parallel cuts one twelfth to one eighth of an inch apart, and the long strips are cut into lengths of about 1 to 1½ inches

Brittain describes his operation as follows

"The aponeurosis covering the erector spinæ is incised on each side of the spinous processes throughout the length of the wound the incisions being separated by ½ inch. The laminae are denuded of muscle by elevators on each side, as in the operation by Hibbs. The spinous process in the lower angle of the wound is cleared with an elevator on each side and also on its inferior aspect. The processes are divided at their base with bone forceps, starting with the most inferior and proceeding up the wound the interspinous ligaments and the aponeurosis being left attached. They are reflected upwards in one attached piece at the upper angle of the wound. The laminae, which have been cleared laterally as far as the lateral vertebral joints, are roughened with bone elevators. It may be desirable to remove the cartilage from the lateral vertebral joints also. Where possible, the periosteal surfaces of the laminae are raised up, but are left attached to the laminae at the outer margin of the wound. The lower half of the bases of the spinous processes are removed and the chip grafts are poured into the prepared

bed throughout the length of the wound. Their disposition is important. They should be placed fitting accurately with each other and with transverse grafts on the weak points between the vertebrae, as a brick layer places his bricks. The processes are then replaced and the aponeurosis carefully sutured on each side, thus enclosing the grafts in their bed and supplying an extra layer of bone on the superficial aspect. It might be said that the 'lid' is put on the box."

AFTER TREATMENT

After all these operations a plaster jacket is applied, or, preferably the patient is placed in a previously made plaster shell, in which he is immobilized for at least six months. Thereafter a celluloid jacket is worn for a similar period.

The operative treatment of spinal tuberculosis is in high favour in America and a high percentage of successful results is recorded. In 90 per cent of Hibbs' cases, the disease was apparently arrested, while Albee reported 92 per cent of successes. In this country opinion is more guarded, and the operation is reserved, with but few exceptions, for adult cases.

TUBERCULOSIS OF THE SHORT LONG BONES OF THE HANDS AND FEET

The short long bones of the hand and foot—the metacarpals metatarsals and phalanges—are frequently the site of tuberculous infection during childhood. The condition is alternatively known as tuberculous dactylitis or spina ventosa, the latter in virtue of the aching pain (spina) and the spindle shaped swelling (ventosa).

The disease becomes increasingly uncommon after the age of five. Up till then, the bone demands a lavish blood supply which is provided by the large nutrient vessel, but after that age, the nutrient vessel gradually diminishes, and with it the liability to tuberculous inoculation of the marrow.

The disease usually affects more than one bone, and not infrequently its distribution is symmetrical. The hand is rather more frequently involved than the foot. The interior of the bone is converted into tuberculous granulation tissue, the lamellae being absorbed, or forming sequestra. Successive layers of new bone are deposited below the periosteum as the disease extends in the interior. Should the tuberculous debris penetrate the shell of new bone, a superficial cold abscess develops.

CLINICAL FEATURES

A fusiform or spindle shaped swelling gradually becomes apparent in the situation of one of the short long bones. The swelling is not associated with any great degree of disability, but occasionally is painful.

After persisting for a considerable time, it may gradually recede,



FIG. 147.—Tuberculous Dactylitis of the 3rd Metacarpal.



FIG. 148. Tuberculosis of Bones. (Boy 3 years old.) Shortening of the middle finger, the result of Tuberculous Disease of the Metacarpal Bone.

and the condition be spontaneously cured. More commonly, a cold abscess forms which gradually erupts on the surface, with the formation of one or more sinuses, usually on the lateral aspect of the fingers. Such sinuses are apt to prove intractable, and discharge of pus and sequestra may continue for a long time.

Healing is apt to be followed by deformity, in the nature of shortening or contracture.

On radiological examination, the affected bone appears expanded, there is a deposit of new sub periosteal bone, and the centre of the shaft is occupied by a cyst-like cavity.

DIAGNOSIS

Tuberculous dactylitis must be distinguished from

(1) Syphilitic Dactylitis. Here the new bone formation is more abundant, the Wassermann reaction is positive, and there are usually other evidences of specific infection.

(2) Multiple Central Enchondromata. There is little or no new bone deposit, and the enlargement is less likely to be fusiform.

TREATMENT

The outlook in tuberculous dactylitis is good, the parts react well to the usual immobilization treatment.

In the hand, fixation is easily secured by anterior and posterior splints, which enclose the whole hand and are held in position by adhesive strapping.

When the foot is infected, a plaster of Paris case is applied for six months or longer to control both the foot and the ankle. When multiple sinuses are present, it may be advisable to amputate the digit, since a quicker cure results. The great toe must always be treated along conservative lines; its retention is all important for the later function of the foot.

CHAPTER VI

TUBERCULOSIS OF JOINTS

Infection of a joint with tuberculosis is nearly always secondary to an infection of some other area usually the lymphatic glands at the root of the lung or in the mesentery. The lymphatic disease is the primary lesion and in most cases, more dangerous than the joint lesion, since it is deeply seated not susceptible to radical treatment and easily overlooked. The infecting organisms are either the bovine or human type of the tubercle bacillus. These can be differentiated as a result of animal inoculation although the lesions they produce are identical. In infection of the human type, introduction may be by inhalation. The drinking of infected milk and the ingestion of infected butter are responsible for the bovine type which is commonest in children.

ETIOLOGY

Tuberculous arthritis is chiefly met with in childhood the great majority of patients being under 14 years of age. There is frequently a history of trauma which may determine the site of infection, but cannot be considered an important antecedent. Direct hereditary transmission is rare. The more probable event is infection of a susceptible child from without.

PATHOLOGY

As a rule there is a primary infection of lymphatic glands from which the bacillus spreads by the blood stream or the lymphatics to the synovial membrane or the bone. A mild Septicæmia may ensue. An injury near a joint may lead to infection of the epiphysis with subsequent joint implication. Symptoms suggestive of joint disease arise when the synovial membrane becomes inflamed.

In the bone a small collection of tubercles is found, and these are seen microscopically to be made up of endothelial cells with as a rule, a few giant cells. The process extends towards the joint and at the same time circumferentially, the bony trabeculae being eroded. There is in the early stage a non tuberculous synovitis, but the synovial membrane soon becomes thickened, hyperæmic, and studded with tubercles. Granulations spread from the synovial infection over and under the cartilage with resulting ulceration and exposure of under

lying bone and at the same time, the capsule and tissues may be involved.

⑥ Muscular spasm is a common accompaniment, so that the bone-ends are pulled together, softened and eroded. The debris thus formed is the main constituent of the pus which is found in or around the joint. Not infrequently a segment of bone becomes detached and forms a sequestrum.

Repair may occur at any stage, either spontaneously from the recuperative power of the patient, or initiated by appropriate treatment. Healing results in the formation of fibrous tissue from the granulations, leading to dense fibrous adhesions and ankylosis. The abscess may be acute or chronic, the latter being the so-called residual abscess, merely the debris of the burned-out disease.

Histopathology. In the early stages there is a collection of endothelial cells, surrounded by lymphocytes. Later, groups of the cells coalesce to form giant cells of the foreign body type, surrounded by amorphous material. Occlusion of blood-vessels, aided by the toxins, leads to disintegration and caseation. Bacilli escape from this focus to form new tubercles, which in turn coalesce, and so enlarge the area of disease. When the active process subsides the tuberculous nodule becomes encapsuled but remains as a potentially active focus.

SYMPTOMS

The early signs are those of a chronic inflammation—an insidious mono-articular synovitis. In addition to fluid in the joint there is swelling of the synovial membrane and the capsule, and the peri-articular structures are oedematous. There is early and persistent muscular atrophy, and muscular spasm is also a characteristic symptom. Pain is irregular, and when present may be referred to some distal part of the limb, as for instance the medial side of the knee in hip joint disease; it may be constant or elicited only by movement. The early limitation of movement of the joint is a reaction to the pain, the muscles contracting to steady the limb. Deformity, unless prevented by appropriate mechanical treatment, sets in early, and is caused, in the early stage by muscular spasm, and later, by organic muscular shortening. This muscular shortening, in addition to producing flexion, may cause an actual displacement of the bones, such as is so frequently seen in a tuberculous knee, where subluxation with backward displacement of the tibia on the femur occurs.

Shortening of the limb is produced in two ways; either there is a retardation of growth in length, at the epiphysis, or, at a later stage, shortening from actual bone destruction.

Albee states that the common manifestations of joint tuberculosis in the order of their appearance are stiffness; limitation of movement; alteration of position; pain; night cries; elevation of surface temperature and tenderness; muscular rigidity and spasm; swelling; muscular atrophy; alteration in bony outlines; and abscess formation.

In addition to those local signs there are some of a more general nature. The patient's health suffers and he fails to gain, or actually loses, weight growth is retarded and there is pyrexia. Pain and loss of sleep account for some of these constitutional signs, but the pyrexia is an indication of toxæmia due to active disease.

Complications The most frequent complications are abscesses, secondary infection of sinuses, and tuberculous meningitis. Secondary infection is the most common late complication, and gives rise to increased fever, night sweats and wasting. The prolonged suppuration leads to waxy disease.
(Amyloidosis)

DIAGNOSIS

The only positive evidence that a joint infection is of a tuberculous nature is the identification of the organism from the joint or its neighbourhood, the histological identification of the disease in tissue from the joint, or the reproduction of the disease by the inoculation of a guinea pig with material from the joint.

Various methods may be used to establish the diagnosis of tuberculosis in chronic arthritis, any one of which may be misleading. Nevertheless by making use of all of them a correct diagnosis may be achieved.

(1) **The Guinea-Pig Test** This is the most convenient method when there is fluid available for inoculation. It is obviously better to inject two guinea pigs in every case. In arriving at a conclusion distinction has to be made between the case with an actual infection of the joint and a symptomatic synovitis from a para articular focus, the fluid from the latter is sterile. The guinea pig test, then, is decisive only when the result is positive, whereas a repeatedly negative result does not preclude tuberculosis.

(2) **The Tuberculin Test** A positive Mantoux test is of significance only in the first three or four years of life, after which 50 per cent of the population give a positive reaction. On the other hand Sundt points out that a negative Mantoux reaction does not preclude active bone or joint tubercle. He says that the only convincing proofs are firstly the absolutely negative result of all tuberculin tests including the subcutaneous up to an injection of 10 mgm of old tuberculin and secondly, a focal reaction that, both objectively and subjectively, is undoubtedly positive. The focal reaction is not devoid of danger, however, and it is doubtful, too, whether it is specific.

(3) **Radiographic Appearance** There is no picture that is entirely typical of joint tuberculosis in any of its stages, but the following points are at least suggestive. At an early stage the X ray examination is usually negative. The earliest sign is an increased radiability of the bones related to the affected joint. Later signs are a localized area of diminished density in the bone and increased joint space thickening.

of the synovial membrane and an irregularity of the joint outline. The later films show clearly a gross destructive lesion of the joint with absorption of bone loss of continuity of the joint, and dislocation. With healing there is gradual replacement and condensation of bone but any gross deformity persists.

(4) **Wassermann Reaction** In all doubtful cases it is the rule to exclude syphilis by the Wassermann reaction.

(5) **Exploratory Arthrotomy** In exploration of the joint should be regarded as a last resort though there is no doubt that it is a justifiable procedure in adults and, in the writer's opinion in children. Microscopically there is marked similarity to syphilis which must always be remembered and indeed a certain histological diagnosis may be impossible. The tissue however may be cultured or a guinea pig inoculated.

(6) A biopsy of the regional lymph nodes where possible is often useful. The inguinal gland may show evidence of tubercle in a doubtful knee joint.

DIFFERENTIAL DIAGNOSIS

Acute pyogenic arthritis is distinguished by its sudden onset subsequent clinical history and radiological appearance.

Syphilis is similarly differentiated. A positive Wassermann reaction is helpful.

Emphysema may present great difficulty but it gives a very distinctive X-ray picture.

PROGNOSIS

Once the joint is invaded complete restoration of function is unlikely so much so that when perfect cure results the diagnosis is open to doubt. But though the joint function may be greatly disturbed the danger to life is not serious if treatment is efficiently carried out. Where death ensues it is usually due to secondary infection or some other complication. The mortality which is comparatively low is greater in spine and hip cases and less in the upper than in the lower extremity.

Statistics of the effect on joint function vary enormously. Jungling of the Tübingen Clinic discussing results of treatment in 117 cases of knee tubercle is found 80 per cent with full mobility while L. Pattison had 55 per cent in 300 cases affecting the hip joint. These percentages greatly exceed the figures noted at most clinics for as a rule it is found that however mild the disease and however careful the treatment some limitation of mobility persists.

Sir Robert Jones considered that the prognosis is better in children in that particularly bad cases are a very acute onset high fever much pain poor bone content is seen by X-ray examination at least thickening of the joint.

TREATMENT

The treatment must be both local and general. It may be conveniently discussed under four heads—(a) general (b) local (c) operative and (d) the treatment of complications

(a) General Treatment

Rest, liberal diet, and hygienic surroundings are essential

Heliotherapy is scientific treatment by light rays. In this country, for obvious reasons, dependence is placed chiefly on artificial sunlight. It is claimed that by its judicious use physiological functions are stimulated, muscular tone restored, the bones strengthened and circulation and respiration improved. The degree of pigmentation induced is an index of the efficacy of the treatment and it is said that even a negro becomes darker if the response is satisfactory.

Although light treatment is so important it must not be forgotten that fresh air and especially exposure to fresh air is almost as beneficial. In many of the cases tuberculin is used to improve the natural immunity. A small quantity of 5-10 per cent Moro's ointment rubbed into the skin once a week may be useful in children. Beraueck's tuberculin in increasing strengths and used over a long period of time is of some value in joint cases.

(b) Local Treatment

The local treatment includes reduction of deformity, traction, fixation of the joint in the desired position and protection until the healing is complete.

Reduction of Deformity. It is of the utmost importance to secure the limb in such a position that should ankylosis supervene the greatest possible functional utility will be attained. Attention must therefore be directed to the reduction of any deformity and to the fixation of the joint in the desired position. A flexed knee for instance must be more or less extended and a dropped wrist dorsiflexed. This reduction is commonly effected by gradual traction. The pull made at first in the line of the deformity is modified in direction as the stiffness diminishes until the desired result is secured. Rapid reduction under an anæsthetic a method known as Brisement Force is to be deprecated on account of its risks.

When the deformity is reduced a decision must be reached on the ultimate aim—a stiff painless joint or a movable one? The prognosis will be based on the extent of the disease as shown by the radiogram.

When the bone is diseased a stiff joint is probable though sometimes after a long period of fixation with ankylosis in view a surprising degree of movement remains. The joint is encased in plaster of Paris except in very young patients or in those with sinuses and in order to obtain complete immobility the plaster case should include the joints on both sides of the affected one. The duration of this treatment depends on many factors—age site of disease etc. but a minimum period of six

months is indicated. In certain joints a splint may be used as an alternative during this period, e.g. the Pyrford frame in hip cases.

When the disease is mainly synovial with little affection of bone, a movable joint should be the aim. The extent of movement will depend on the length of adhesions between the joint surfaces, hence the object of treatment in these cases is to keep the surfaces as far apart as possible by means of traction which is more frequently used in the lower limb. The duration of treatment in this phase is approximately the same as in the fixation stage and lasts until there is no evidence of active disease and healing is far advanced or complete.

The last stage is that of protection care being taken to guard the joint against injury. During the first few months of this stage, the patient is confined to bed, but finally ambulant treatment is employed. Subsequently, careful supervision is essential until a reasonable certainty of cure is established.

(c) Operative Treatment

In the majority of cases conservative treatment is the method of choice, but certain conditions definitely indicate operation. The duration of the disease tends to be shortened thereby, though interference with joint function is more likely to result.

The operation of excision may be advisable in a destructive lesion in an adult, but it is not attended with favourable results in the young child, chiefly because the disease is usually more extensive than is shown in the radiogram and therefore excision of a considerable area of bone is necessary. This would naturally interfere with growing epiphyses and lead to a shortening of the limb in later years. Further it is held that trauma to the tissues by surgical interference tends to stimulate the progress of the disease. In adults the inflammation is, as a rule, more painful and more acute, and conservative treatment would occupy several years while excision of the joint may lead to cure in six months. A fixed joint results, this however, is probable even after several years of conservative treatment.

In addition to excision of tuberculous joints there are important extra-articular forms of operation, whereby a joint is fixed by means of an internal splint without any damage to the joint tissues which are the site of the disease. These operations, which are described elsewhere, are carried out more frequently in diseases of the spine and hip.

(d) Treatment of Tuberculous Abscesses

A residual abscess is more easily cured than an acute one. The tendency in the treatment of both is to be conservative, and a considerable number of abscesses disappear under this treatment. A more active therapy is indicated when there is tension of the skin, or where pressure is being exerted on vital parts.

Aspiration. It is sometimes possible to effect a cure by repeated emptying of the abscess. A wide bore needle is inserted obliquely through healthy skin and pushed on until it enters the abscess cavity, the contents of which are removed by aspiration. The needle is with

drawn and the puncture sealed with collodion. In certain cases the thickness of the pus precludes aspiration and incision is necessary. When this is for any reason undesirable an attempt may be made to liquefy the pus by the injection of certain substances. Thymol mixed with camphor in the proportion of 1 : 2 sometimes succeeds. Other substances are injected with the aim of producing irritation and subsequent fibrosis. Calve claims good results from the use of the following mixture which he terms Sclerogenic Fluid.

| | |
|-------------------|-------|
| Iodoform | 3 pts |
| Ether | 10 |
| Guaiacol | 2 |
| Creosote | 2 |
| Sterile Olive Oil | 100 |

Incision is called for when the skin is discoloured and threatens to give way or when the abscess is spreading. A small opening is made under aseptic precautions and the pus allowed to escape. Unnecessary handling of the parts is to be avoided. If a drain is inserted it should not be retained longer than twenty-four hours lest a sinus be established.

In certain cases Sorrell recommends a form of treatment similar to that used by Winnet Orr for osteomyelitis. The deformity having been corrected the abscess is opened, sterilized with 5 per cent iodine solution and freely drained. The parts are then encased in plaster of Paris. Immobility, drainage and safeguards against contamination of the wound from dressings are thus established. The limb is left in plaster for several months. If possible steps should be taken to obviate the disagreeable odour that tends to arise from beneath the plaster.

TUBERCULOSIS OF THE HIP JOINT

As a rule tuberculous disease affects the hip joint before the age of 10. Its incidence is less than that of spinal disease, the ratio being about 7 to 10. In over 4,000 cases admitted to East Fortune Sanatorium the hip was involved in 18 per cent of the cases of bone and joint lesions. It is slightly commoner in males.

PATHOLOGY

The usual initial bone site of the disease is in the upper part of the acetabulum or in the so-called Babcock's Triangle, i.e. the lower half of the neck of the femur near the epiphyseal line, but it may be synovial in origin. However it is doubtful if the localization of the original focus is of much practical importance since even if it is extra-articular it is not likely to be successfully extirpated.

When disease begins near the epiphyseal cartilage of the head of the femur—a place where the circulation is active and the growing bone less resistant—an area of infected granulations forms which spreads towards the joint. These granulations extend gradually over and under the cartilage which they ultimately destroy and finally

attack the bones comprising the joint. In the early stage there is a simple effusion but the fluid soon becomes infected with tubercle and the whole joint is invaded by the disease. The synovial membrane becomes thickened oedematous grey and ulcerated and the bones denuded of their protective cartilage are eroded and sequestra may form. As the disease progresses the head of the femur is partly absorbed the remnants being dislocated from the acetabulum on to the ilium where a false joint is formed. This is constantly pushed upwards by the muscles acting on the head giving rise to the so-called wandering or migratory acetabulum (6).

At a later stage the pus which has formed bursts through the capsule and spreads in the lines of least resistance. It may point in the groin in the neighbourhood of the great trochanter or by perforating the acetabulum, appear as a pelvic abscess.

If left untreated healing may take place eventually by absorption and connective tissue encapsulation but there results much distortion deformity and ankylosis of the joint.

SYMPTOMS

The disease is insidious in its onset and chronic in its course.

As a rule before definite signs appear there is evidence of malaise the child being pale and apathetic and the appetite poor. One of the first symptoms is stiffness of the limb which is present on first getting out of bed but passes off

during the forenoon it returns however on a subsequent day and causes the child to limp. Both stiffness and limp tend to persist more and more. Pain may be absent in the early stage or when present be referred to the knee. Later the child begins to cry out during sleep though on waking there may be no complaint of pain. This cry is elicited by the so-called starting pains caused by the friction of the two diseased surfaces where apposition is permitted by the muscular relaxation that sleep produces. The symptoms, stiffness and pain of the cartilages of the joint.

Among the symptoms of general debility loss of weight and emaciation are often noted. Should an abscess form the pyrexia will be more marked. At a later stage pain and deformity coupled with general malaise preclude walking. The general health deteriorates rapidly when abscesses form especially if suppuration results.

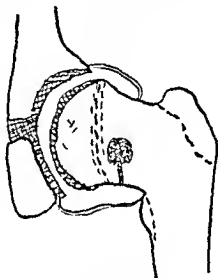


Fig. 141—Tuberculosis of the Hip.
A early focus in the neighbourhood of the greater trochanter.

Sir Robert Jones described three types (1) a rapid severe type which is acutely painful and rapidly destructive (2) the usual type with moderate pain but no great general disturbance and (3) a slowly progressive form with little pain marked deformity and stiffness, going on without grave bony change for many years. The last type is very resistant to treatment.

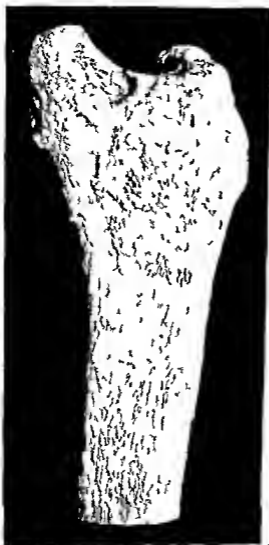


FIG 150 Tuberculosis of the Hip Joint

The disease has resulted in complete destruction of the femoral head and the proximal part of the neck.

PHYSICAL SIGNS

Lameness is one of the first signs. In the early stages it is caused by stiffness or flexion deformity, the body bending forwards to compensate for inability to extend the hip. Later a further limp is produced by pain, the child hastening to take the weight from the affected side. Lastly there is the limp from real shortening.

Inspection The examination should be carefully carried out with the patient undressed and the general effect of the illness may then be seen in the pallor and emaciation. The affected thigh is visibly wasted, the atrophy extending to the gluteal muscles. The deformity and the resulting limp are now obvious differing according to the stage of the disease.

① In the early stage there is flexion adduction and lateral rotation because less weight is borne on the joint.

② in this attitude and there is apparent lengthening of the leg. The flexion at the hip abolishes the normal gluteal fold. As the disease progresses the joint is unable to tolerate any strain so that crutches become necessary and the attitude is now one of flexion adduction and medial rotation with apparent shortening. As the bone becomes eroded and wasted the real shortening supervenes and increases as the

②

③

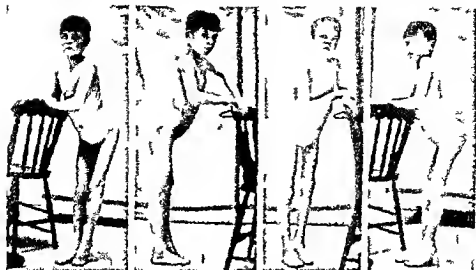


FIG. 131.—Tuberculosis of the Hip

A serious case showing the additional flexion of the right leg to the left.

dislocation of the head of the bone develops There is in addition retardation of growth from disturbance of the epiphysis

Palpation corroborates the findings of inspection. In addition if the region of the neck of the femur is held between the fingers and thumb and compared with that of the opposite side some thickening in the joint may be felt. Abscesses are sought for both in the region of the joint and in the pelvis which is palpated from the rectum.

The range and freedom of movements are determined by comparison with those on the sound side and are limited in all directions. In the early stages this limitation can be more easily detected if the child is placed in the prone position and attempts made to carry out the movements of hyperextension and medial and lateral rotation of the hip. The are markedly less than on the sound side.



FIG. 132.—Multiple Joint Disease in the Hip

✓ Thomas's flexion deformity test is carried out. The good knee and hip are flexed on the abdomen and the child is asked to lay his affected

leg flat on the table. If he cannot do this actively or with slight assistance then there is a flexion deformity present and the test is positive.

Records are taken of the degree of atrophy and of the amount and type of shortening. In estimating the shortening, attention is directed to the distances between the anterior superior spine and the tip of the medial malleolus, and between the latter point and the umbilicus. Comparison is then made with similar measurements on the opposite side. It is important to note the site of the deviation. If the great trochanter is not above Nelaton's line, the site of the deviation is not at the hip joint but lower down.

Radiographic Examination. At an early stage nothing abnormal is noted. The earliest sign is a slight haziness due to synovial oedema.

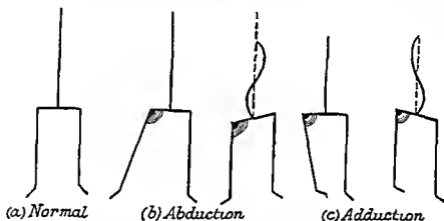


FIG 153—Tuberculosis of the Hip

Diagrammatic representation of the effects of a fixed joint in abduction and adduction. When abducted the pelvis is tilted to permit of the legs being parallel with an apparent lengthening. When adducted the tilting produces apparent shortening. The spine flexes laterally to allow the head to assume its erect position and scoliosis results.

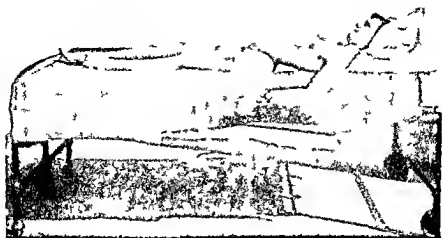
In a few cases, owing to its excessive thickness, it is possible to delineate the synovial membrane, above and below the head. With great effusion the ends of the bones are farther apart than on the sound side. As bone atrophy develops, the affected side gives a thinner shadow, and, still later, an area of destruction is seen, most commonly in Babcock's triangle on the inferior aspect of the cervical side of the epiphysis.

Finally, when the cartilage is eaten away, and more and more bone eroded, the joint outline disappears. The erosion is most marked on the upper hemisphere of the head and the upper part of the acetabulum. These erode each other, leading to dislocation, with a "migratory acetabulum."

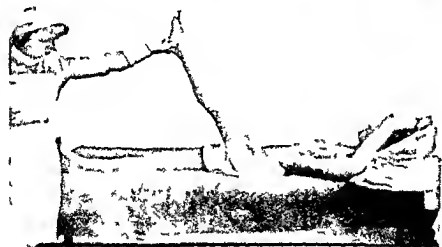
The diagnostic value of Radiography is not great in the early stages of this disease—and indeed negative radiographs do not exclude tuberculosis—but is useful at a later stage in indicating the site and severity of the lesion.

Tuberculin Test If the subcutaneous injection of $\frac{1}{20}$ mgm. of old Tuberculin gives negative results the lesion is not tuberculous. A positive reaction is of less value.

Wassermann Test If syphilis is suspected a serum test should be carried out. A positive Wassermann does not necessarily mean a



(a)



(b)

FIG. 154—(a) An old lesion of Tuberculous Hip Joint with flexion adduction deformity as well as considerable degree of Shortening.

(b) The Thigh is contracted and the amount of actual Shortening is now visible.

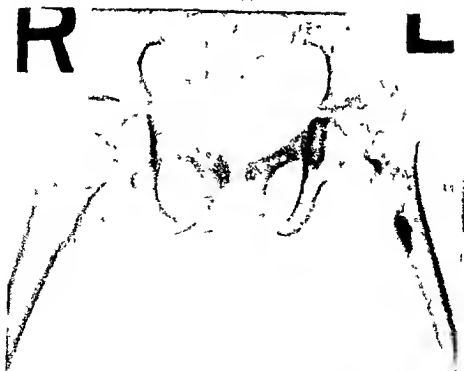
syphilitic arthritis—a very rare condition. It signifies activity of the virus which must be taken into account in treatment.

DIAGNOSIS

The diagnosis is made from the history, the symptoms, and from the physical examination including the roentgenograms. The results of the tuberculin tests can never be taken as final, and a definite diagnosis



(a)



(b)

FIG. 100—A Tuberculous Focus in the Trochanter of the Femur

(a) Note the decalcification in the vicinity of the joint. (b) The tuberculous focus in the trochanter has extended into the joint. The head has become absorbed but there is evidence of healing of the disease in the lessened decalcification. Note the inflammatory areas at work in the tissues of the ilium.

can be made only by the discovery of tubercle bacilli in the fluid or tissue from the joint. It may be necessary to inoculate a guinea pig and note the results (7)

DIFFERENTIAL DIAGNOSIS

Various diseases may simulate a tuberculous hip. These may be



FIG. 106.—Tuberculous focus in the Acetabulum

A history of the disease is seen in the fluffy outline of the lesion and the cavity in the acetabulum.

grouped under the symptoms they produce, viz limitation of movement, discess, lump and pain.

1. Limitation of movement, in tuberculous disease, is caused by spasm of muscles and is observed, therefore, in every direction. (8)

- ① Subacute monoarticular arthritis of the hip is not uncommon in children ② If non tuberculous it will disappear after a few weeks rest The child should be examined every fortnight for a few months
- ③ Hysteria is recognized by the variability of the symptoms the marked hypertonus of the muscle and the absence of wasting
- ④ Upper neurone lesions exhibit spasm which is gradually overcome by pressure There is no wasting and usually there are signs of the disease in other parts of the limb



FIG. 15 —An Early Case of Synovial Disease
Note the local heat on a specially marked in Batcock's or a

④ In reflex irritation, as from inflamed glands or injured reflexors or phimosis limitation is not general as in hip joint disease

2 Abscesses in the Region of the Hip It may be difficult to trace these to their source. If acute there is little difficulty if subacute the possibility of hip disease must be considered. The result of treatment and the examination of pus from the abscess should be specially noted. If the abscess is tuberculous it must be differentiated from a tuberculous infection of the subcutaneous or pyosarcoma in which the limitation of hip movements is not general. It is in these cases that a complete X-ray examination is likely to be of diagnostic value.

3 Limp Lameness may be due to several diseases

(4) Congenital dislocation of the hip is present from birth the head of the femur is in an abnormal position, and certain movements are increased in range. X-ray is decisive.

(5) Coxa Vara. Lateral rotation is increased and there is marked lateral deformity. X-ray examination is of the greatest value.

(6) Pseudocoxalgia (Perthes Disease). Many examinations may be required before a diagnosis can be made in this condition. There is less muscular wasting in Perthes disease, while the radiogram will show more bone changes which in the early stages of a tuberculous hip are few. In Perthes disease the movements are not limited in all directions as in tuberculosis.

4. Pain in the region of the hip may be the predominant symptom in the following diseases:

(1) Osteomyelitis. The main features in this disease are local tenderness and toxæmia. A differential white blood count shows a polymorphonuclear leucocytosis. In tubercle there is a lymphocytosis.

(2) Slipped Epiphysis. The severity of the pain, eversion, shortening and absence of wasting are suggestive. X-ray examination at once reveals the nature of the condition.

(3) Poliomyelitis has a more sudden onset often arising during an epidemic. The muscles are markedly hyperæsthetic and tender. In a few days the joint can be moved freely in all directions.

PROGNOSIS

With early diagnosis and efficient treatment the mortality should be very low.

An undue intensity of any symptom is unfavourable. The danger both to life and to function is greater in adults. Sir Robert Jones believed that if the damage is sufficient to make the diagnosis of tubercle certain, some impairment of function will result.

When the head is affected the result is always doubtful, and if there is much bone destruction ankylosis in a good position is the limit of cure. In this variety there is a marked tendency to adduction, even after treatment has been carried out for a long period.

Interesting figures regarding end results have recently been published from the New York Orthopaedic Hospital. During a period of seventeen years 208 cases were treated, 46 of which were excluded from the statistics owing to errors in diagnosis. In a final study of 150 patients 24 per cent had died, in 47 per cent the disease was active, in 27 per cent quiescent at the date of examination, two patients were free from symptoms and had a useful range of movement. On the other hand, there are the statistics of L. Pittison already quoted.

TREATMENT

1. General Treatment

Liberal diet, fresh air, sunshine, discipline, education or occupation and supervision in a suitable institution, are all of great importance.



152 Tuberculosis of the Hip and Sacrospinous Joint (a) After the reduction
12 months later

Without them, local treatment avails little. As Perkins said: "The surgeon does nothing to assist the local cure of the disease. It is the general treatment which enables the patient himself to stamp out the local manifestations of the disease. Attention however must be directed to any local disabilities and to this end the joint must be placed in the position that will provide the greatest functional utility when the cure has been established."

2 Local Treatment

This will vary according to the extent of the disease. If it is advanced there is probably some deformity present usually a combination of flexion and adduction from strong muscular contraction. Before further treatment can be initiated, this deformity must be corrected and any pain that is present alleviated. If the patient is seen before pain and deformity have developed curative treatment is commenced at once.

(a) Stage of Acute Symptoms. When the patient is suffering acute pain in the joint is unable to move without great distress and is frequently wakened at night by pain arising from friction between the inflamed joint surfaces, no treatment gives speedier relief than traction applied to the limb by means of webbing, strapping and bandages. Plaster strapping is often preferable to the less stable webbing. It gives a more certain pull and requires less adjustment though it has the disadvantage of being more irritating to the skin. After the application of the extension strapping the limb is placed in a Thomas's knee splint to steady it and ensure extension in the proper direction. The actual pull on the extension may be by a weight led over a pulley at the foot of the bed or by the Spanish windlass method which acts by the twisting of the two lateral extension cords already looped over the end of the splint with a small lath of wood. If the weight method is used the amount required is approximately one pound for every year of age, the foot of the bed being raised so that a counter extension is formed by the weight of the body. To steady the pelvis and to prevent compensatory movements of adduction of the other leg a long Liston splint is applied to the opposite side of the body.

The correction of the adduction during the period of treatment by traction is occasionally complicated by the development of a genu valgum owing to the traction exerted by the lateral pull on the medial collateral ligament of the knee joint. This complication is prevented by a special method of incorporating the traction plaster in a plaster of Paris mould extending to the mid thigh. The method is seen in Fig. 160.

The actual degree of deformity is estimated in the first place by getting rid of the compensatory tilting of the pelvis from lordosis and by the abduction of the opposite leg the traction being then arranged to pull in the line of the deformity. This direction can be adjusted by fixing a Thomas's splint to wooden uprights and cross bars fixed to the bed.

The extension pulls on the opposing joint surfaces thereby abolishing the spasm of muscle which causes flexion adduction. Each day this traction is inspected and its direction modified, and in a few weeks the deformity will be corrected sufficiently to ensure a useful position.

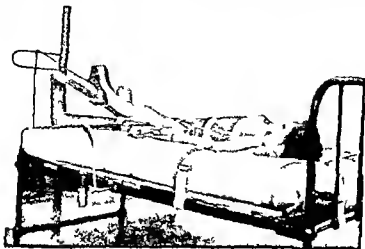


FIG 159—Tuberculosis of the Hip The treatment in the acute stage

The reduction of the deformity is brought about by fixing the unaffected side of the pelvis with a long Li ton splint and applying longitudinal and lateral traction to the affected limb.

should ankylosis ensue which is known as the optimum functional position. It varies somewhat according to the extent of the disease and the possibilities of treatment, the greater the real shortening the more extensive must the abduction be but even without bone disease



FIG 160—Plaster-of-Paris Case applied to prevent over stretching of Medial Collateral Ligament of knee when correcting Adduction by Traction.

abduction is advisable as with adhesions in the joint, the tendency during convalescence is towards adduction.

It is sometimes recommended that cross traction should be applied to pull the head away from close contact with the acetabulum. In practice, however it is not found that this treatment has any advantage either in the relief of pain or in its ultimate results. Thus cross traction can be

applied by passing a sling round the upper end of the thigh attaching a weight to its free end and allowing it to hang over the edge of the bed. A similar sling and weight are applied round the pelvis and hung over the other side of the bed so that counter traction is effected.

(b) Stage of Cure When the acute symptoms, particularly pain and spasm, have subsided and the deformity has been treated, it is

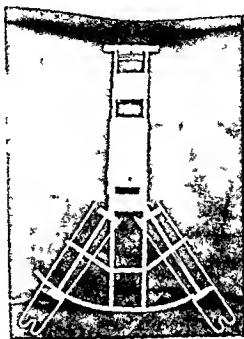


FIG. 161.—The Pyrford Frame.

necessary to decide whether or not a movable joint is to be aimed at. This difficult question is decided by the X-ray picture. If the head of the bone is much eroded or there is much disease on the acetabular surface, it is almost certain that ankylosis will ensue. It is true that, occasionally, a much eroded joint after months in plaster, shows considerable movement. This, however, may be painful and in any case its functional value is inconsiderable. It is wise, in all adults and in



FIG 162—The Pyrford Frame in use

is that known as the Pyrford hip frame. It is an ingenious combina-
 tion of the ordinary Bradford frame used for spinal cases, with two Thomas's knee splints fixed to the frame at the level of the hip joint which are movable to permit of adjustment of abduction. The body, pelvis and legs of the patient are by this means most efficiently controlled and the frame is so constructed that the functions of the bowel and bladder can be attended to with a minimum of movement. The body and pelvis of the patient are fixed by means of webbing harness, while the legs are controlled and extended by traction plasters the cords of which may be adjusted round the terminal V of the modified Thomas's knee splint. As it is

all but a minority of children, and where destruction of bone is extensive, to aim at ankylosis. When the disease is synovial or when there is a focus in the neck of the femur, treatment is based on the assumption that a mobile joint may result.

(A) Cases where there is hope of a movable joint

Any case therefore coming under the latter category is treated by traction with the object of separating the articular surfaces and preventing bony ankylosis. If this attempt is successful any stiffness that remains is due to fibrous adhesions and the range of movement will depend on their length.

The splint recommended for children up to the age of seven

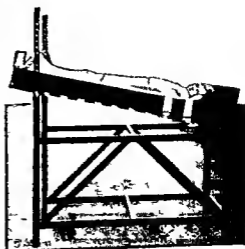


FIG 163—Treatment of the Synovial Type of Disease by Traction in a Berek Tray

Traction plasters are fixed to the leg on the affected side and these are secured to the lower end of the tray. The tray is then tilted to an angle of 45° and this gradually corrects the deformity and produces an abduction by pulling down the pelvis on the affected side.

at the splint should fit the patient accurately, an individual rule required. This frame is particularly useful when an abscess is present or an abscess which requires aspiration and abscesses can be effectively controlled by it.

and heavier children the Pyrford frame tends to be unstable. A very effective and simple method of treatment in this case is by means of the Berck tray. The limb is fixed to the bottom of the tray, and the foot is elevated on a special frame so that the patient's body angle of 45 degrees with the ground. The weight of the body is on the joint.

at the same time of the affected side since a weight tends to swing underneath its. When the pelvis is never the child spine laterally to add under the sup.

and in this way produce a scoliosis. a case therefore careful watching and be left in the frame. Renal calculi are common easily in this position but are by frequent lower increased fluid intake where ankylosis is



FIG. 164.—Treatment of the Second Stage by a plaster of Paris cast.

Note the moulding to secure limb fixation.

majority of patients never ankylosis is of treatment and best be seen by

the hip with plaster of Paris. In applying the plaster to be borne in mind that the hip will ultimately be fixed in the chosen position. The optimum position for ankylosis varies and apparently with the individual surgeon but it is important to remember that growth will almost certainly be diminished, recently diminished and that the only compensation apart from leg lengthening operations is an abduction extension. In cases therefore where there is much disease in the region of the epiphysis a moderate amount of abduction is preferred. The limb is placed in a neutral position of rotation, or just degrees of external rotation. The position of flexion chosen

- varies with the age and Girdlestone says one degree for each year of life up to twenty degrees then a little more. The patient with an ankylosed hip cannot sit and walk comfortably as he is most comfortable walking with an extended hip while a flexed hip suits him best for sitting. Something between the two has therefore to be chosen and his wishes and occupation have to be considered. The angle varies with age as the young spine is so much more a laptable and what it has learned in youth will help for many years.

There is an art in applying a plaster splint so that the maximum of immobilization is achieved with a minimum of pressure and it is only by skill and experience that this is acquired. The plaster case is applied over a thin flannel vest with a padding of felt over the bony prominences and it reaches from the nipple line to the toes of the affected limb, being accurately moulded over the pelvis and waist line. There are so few fixed points in the body to prevent upward displacement of the leg that it is necessary to carry the plaster up to the nipple line. A so called plaster hip spica with a narrow band round the pelvis is worse than useless as it gives a false sense of security and yet allows the long pelvi femoral muscles to crush the head and the acetabulum together and produce a mechanical erosion of the bone. The tuberculous erosion of the bone cannot be prevented but only influenced by treatment but efficient treatment should certainly prevent the mechanical wasting of the bone. It is not usual or necessary to include the sound limb unless some special circumstance demands it. The plaster precludes all movements at the hip joint and by its extension to the chest prevents the patient from sitting up and thus obviates any possibility of its being cracked.

These then are the two methods by which the hip is treated in the second stage, which stage lasts for a variable time, rarely less than a year and often longer. When the disease is no longer active, the convalescent stage begins. Unfortunately it is often difficult to say definitely when all activity has ceased—no single sign suffices. If the local signs of disease have disappeared and if the patient has a good appetite is gaining weight and has no pyrexia the disease is probably quiescent. X rays are not of great value, but they may show that the appearance of decalcification is being replaced by that of more normal density.

If complete freedom of movement be allowed within the limits of confinement to bed and the patient examined daily it will be found in favourable cases that the joint gains daily in mobility and that there is an absence of spasm. Gauvain attaches great importance to the presence of muscular spasm in doubtful cases.

(c) Stage of Convalescence. At the end of the previous stage when there is evidence that the disease is arrested, ambulatory treatment begins. In most cases there is an intervening period of about three months when the patient is allowed freedom in bed unhampered by any apparatus. During this time he is measured for an ordinary

Thomas's walking caliper and a patten is fixed to the boot on the sound side. At first he is allowed up with a patten on his good side and crutches so discouraging if not preventing weight bearing. In three to six months he is allowed to wear his Thomas's walking caliper and discard the patten and thereafter the crutches.

Ambulatory treatment is divided into stages so that full function is attained gradually. It is of the utmost importance that this splint should fit the patient correctly. Two things at least are essential for a properly fitting splint: the tuberosity of the ischium must rest on the ring of the caliper and not slip through it, and there must be a space between the heel of the foot and the heel of the boot when the patient is standing upright. If these conditions are fulfilled no weight is transmitted through the hip joint and thus avoidance of weight bear-

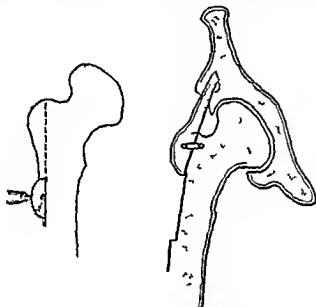


FIG. 116A. The trochanteric graft of Hildner.

ing must be insured during the first stage of ambulatory treatment when the patient uses his caliper and crutches with a patten on the sound side. The patient is usually advised to wear his caliper for at least a year during which time he should be examined at regular intervals, though the patten is removed after about six months and the crutches discarded three months later. After all apparatus has been discarded he is asked to report every three months for three years. This constant supervision may appear irksome but the examination occupies only a few minutes and is imperative if the best possible results are to be achieved.

3 Operative Treatment

In every case where ankyrosis is to be expected the question of the operative production of this is to be considered as in many cases

conservative treatment does not cure the disease but produces a state of chronic invalidism and also in many favourable cases it takes a very long time for recovery to be effected. It is a wise practice however to treat all cases, and certainly all children, conservatively for at least a year and to reserve consideration of operation only for those cases which do not show a good response within such a period. It has been stated that there are four main indications for operation— (1) in an adult patient (2) failure of conservative treatment to arrest the disease after one or two years (3) relapse, especially the recurrence of pain and deformity after conservative treatment (4) certain destructive lesions e.g. the formation of sequestra in the head or neck of the femur or in the acetabulum

The operation may be directed to the treatment of the primary disease or to improvement of the function of the limb which has been the seat of the disease

(a) **Primary Operations** Not long ago when these cases were treated in general hospitals excision of the head of the femur and the infected tissues round about was carried out almost as a routine the results however were uniformly bad and the operation is no longer practised. The head may be removed if it forms a sequestrum in a secondarily infected cavity, but otherwise no surgical attempt should be made to remove the infected tissues. Stiles published his results in 40 cases of excision of the joint and had a mortality of 20 per cent within six months of the operation. Bankhart now practises a much more formidable type of excision removing the acetabulum itself by division of the ilium above and the pubis and ischium below the socket as well as the head and neck of the femur. He records an 18 per cent mortality in 9 cases. Such heroic treatment is not advisable

Arthrodesis It is performed on the same lines as an arthrodesis of the spine and to the same extent forms an internal splint, by this means the operation hastens the fusion of the joint and shortens the convalescence of the illness. It is inadvisable before the age of ten years and even in older patients the author does not recommend it unless there is definite disease in the bone. It is indicated in patients who have frequent painful attacks with extreme shortening, and a tendency to increasing deformity especially if there are signs pointing to a relapse

Various methods of arthrodesis of the hip have been described, some of them even opening the joint and removing tuberculous debris before grafting bone into the surfaces. Grafts, however do not do well in the presence of tuberculous disease and accordingly only two methods are described here. The author usually performs the method described by Brittain

(A) *Two femoral Methods of Extra articular Arthrodesis*

In both methods described it is of the utmost importance to keep the

parts firmly fixed after the graft has been inserted and so the operation is carried out with a complete plaster case on and a large window cut out to expose the operation area. Union of the graft has been secured in a much higher percentage of cases since this has been done.

(1) The Trochanteric Graft (Hibbs). This operation is a simple one, and is carried out through a Smith Petersen incision (Fig 165). The upper end of the femur having been exposed the periosteum is incised across the line of the base of the trochanter and elevated. The lateral mass of the trochanter with 2-3 inches of the cortex of the femur,

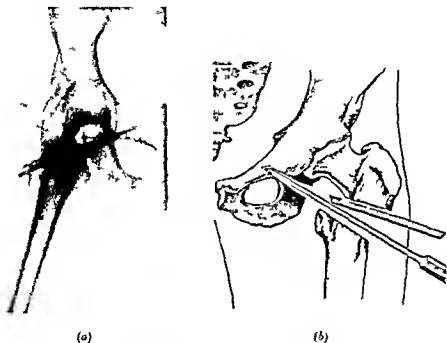


FIG 166.—Arthrodesis by the ischio femoral method

is separated with a chisel, leaving the muscle and the periosteal attachments at its upper end undisturbed. A portion of the ilium above the upper rim of the acetabulum is elevated, without disturbing the muscular or periosteal connections, or loosening its upper attachment. The detached trochanter and part of the shaft are now transposed, by turning the lower end under the elevated mass of the ilium, and making contact with the cancellous bone of the neck from which the cortex has been removed. The thigh is abducted and fixed to the "cottonium" position, and after suture of the wounds a double cast plaster is applied to the pelvis and legs. The fusion which takes place in these cases appears to be primarily between the transposed trochanter, ilium, and neck of the femur, and finally between the remnants of the head and the acetabulum. It will be noted that this is an extra

articular fusion designed to effect internal splinting not to eradicate disease

(2) The Iliac Graft A straight incision is made from the iliac crest directly above the great trochanter and carried down to three inches below the latter. The iliac wing is exposed and the region of the trochanter. The trochanteric tip is levered outwards after an antero-posterior cut is made in it with an osteotome and this cap of bone is levered down and outwards. A fine osteotome is now used to resect a rectangular section of this outer—or it may be outer and inner—cortex of the ilium directly again above the trochanter. The lower end of this graft may be left attached and the graft bent down on this pedicle and turned into the cleft on the great trochanter already prepared for it. A greenstick fracture of the pedicle may occur but this does not affect the operation and indeed the author has seen Harris of Toronto doing a similar operation by completely detaching the iliac graft and sliding it down to cover the ilium neck and part of the trochanter.

No definite rule can be laid down for the length of post operative immobilization and recumbency. It is generally thought best to keep the fused hip fixed in a double spica until union is clinically firm fusion being demonstrated by X ray.

(B) Ischio femoral Method of Extra articular Arthrodesis (Brittain) Brittain has pointed out that the above methods have a common disadvantage in that while fusion is taking place the hip joint is subjected to the predominant force of all action and that any graft from the ilium to the great trochanter may lose contact at either end. Calve and Trumble have both suggested and in the latter case carried out the obvious alternative of an ischio femoral arthrodesis. Brittain however has simplified the method and made it a more practical proposition. This operation consists of a subtrochanteric osteotomy through which the ischium is incised below the acetabulum is incised by a wide osteotome and a space made in it to receive a flat massive tibial bone graft. This is embedded deeply in the ischium and its outer part remains between the fragments of the osteotomy.

The Operation With the patient in position on an orthopaedic table a preliminary X ray is taken with a measuring rod strapped on the leg at the level of the trochanter and a Michel clip at a point in the groin at the junction of the upper two thirds and lower third of a line joining the anterior superior spine and the symphysis. By means of the measuring rod the point of entry of the osteotome on the outer aspect of the shaft of the femur can be accurately plotted and the Michel clip will indicate from its position the direction to drive the osteotome. While the radiogram is being developed the stout thick graft which includes the anterior crest and the medial margin is cut from the tibia. The great trochanter is now exposed with a 3 inch straight incision and a subtrochanteric osteotomy performed the site and direction being indicated by the X ray. The ischium should be



(1)
 FIG 167.—Tuberculous Disease of the Hip (a) just before, without Osseous Union and with 1 cm
 (b) 1100m extra-articular arthritis produces a total loss of function in 2 position

entered and divided just below the acetabulum and is contracted about $1\frac{1}{2}$ inches after the femur is divided. Traction is now put on the limb and a second osteotome—both calibrated—is now inserted alongside the first and by means of the calibration and a second X ray it may be seen how much farther the second osteotome may be driven. When the requisite length has been achieved i.e. the ischium divided the second osteotome is removed and the graft inserted, hammered and pushed home so that it is firmly impacted in the ischium. The limb is then abducted so that the lower fragment abuts against the ischium below the graft.

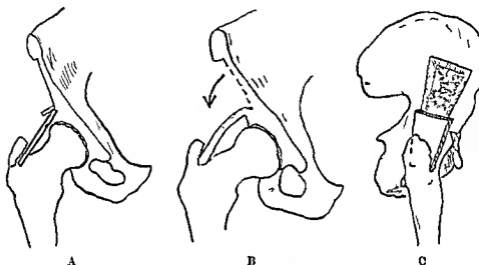


FIG. 168—Methods of Arthrodesis of the Hip Joint. A and B with a pedicled bone flap and C with a free Bone Graft.

(b) Secondary Operations To correct an old-fixed adduction flexion deformity some form of osteotomy is usually employed.

(1) In cases of sound bony ankylosis with adduction flexion deformity a sub trochanteric or a trans trochanteric osteotomy may be performed and the deformity reduced. By this means the excess of shortening from the adduction is overcome and the strain on the lumbar spine relieved.

METHOD A 4 inch lateral incision is made over the proposed site for osteotomy and the femur exposed. To make certain of the exact site of the bone cut it is wise to elevate the soft structures of the shaft in the region of the lesser trochanter and actually palpate the trochanter before making the bone section. But usually the exact site of the osteotomy is ascertained by taking a preliminary X ray photograph while having a measuring stick alongside the bone as is done in performing a McMurray osteotomy. If the abduction correction is carried out immediately there is a chance that the contracted adductors

may displace the upper end of the lower fragment upwards and inwards. This is a serious and shortening complication, and one that is extremely difficult to rectify so no attempt is made to reduce the deformity now, but it is made quite certain that the shaft of the femur is completely divided.

✓To Prevent Displacement of the Fragment A drilling method of osteotomy is sometimes used to make the displacement of the frag-



FIG. 163.—Lorenz Bifurcation Osteotomy.
The body weight is borne directly on the top of the femoral shaft now.

ments more difficult. The incision is made a little more anteriorly and a series of drill holes made in the femoral shaft in a semicircular line with its concavity downwards. The actual severance is made with a narrow osteotome cutting through successively the bridges of bone between the drill holes. The ends are thus more ragged and irregular and tend to hold their position better.

The leg is put up in traction for a period of three weeks, during which time a certain amount of soft callus forms round the bone section. An anesthetic is now given and the deformity corrected by abducting

the limb to the required extent. Since the desire is to get the limbs of equal length, and in such a position that they will be parallel when walking, the amount of abduction must be carefully estimated. While the operator abducts the affected limb his assistant adducts the good limb to its full extent until they are of equal length. Equality of length, however, is secondary in importance to the limbs being parallel and if through contraction of the abductors on the good side equality of length cannot be obtained then one must be content with the maximum amount of compensation of length permitted with the limbs parallel to each other. Great care must also be taken that the lumbar spine is freely movable before such an operation is carried out, as of course it is necessary for the patient to flex his spine to compensate for the altered position of his pelvis. After the required manipulation has been carried out the limb and pelvis are placed in plaster for about three months and it may be necessary then to fit a walking caliper for a further month or two, until union is quite firm.

(2) In some cases the disease is cured only after the head of the femur has become dislocated. In these cases the head cannot be brought down into the original acetabulum, and a modified form of a Lorenz's osteotomy may be practised, where the osteotomy is carried out below the trans trochanteric region in an oblique upward and inward direction. The leg is then abducted, and the inner sharper end of the lower fragment is slid into the region of the acetabulum, while the outer aspect of the upper end of its shaft fuses to the lower and of the proximal fragment (see Fig 169). In such cases the pelvis and leg are placed in a plaster case for about three months.

TUBERCULOSIS OF THE KNEE JOINT

Tuberculosis of the knee is second in frequency to that of the hip joint and, like it, is most common in childhood though it is frequently seen later. In over 4 000 cases admitted to East Fortune Sanatorium the knee was involved in 13 per cent of the cases of bone and joint lesions. It is always secondary to active disease in other parts—usually the lymphatic glands—a point that must never be forgotten in the treatment. Two anatomical points to be noted are the large extent of synovial membrane, and the marked vascularity due to the late junction of the femoral and tibial epiphyses. Growth of the leg takes place in this region, disease of the joint, therefore, is serious because of its possible effect on stature, although in the author's experience shortening is much more serious in hip disease.

PATHOLOGICAL ANATOMY

The disease may begin either in bone, usually in the femoral or tibial epiphysis, or, more rarely, in the patella or the synovial membrane. Hibbs and Smith believe that in 85 per cent of cases the

disease is primarily synovial and this is borne out by the author's experience. Girdlestone describes three groups of cases.

(1) Osseous foci irritating but not infecting the joint. These foci are extra articular, but in contiguity. Excision of the focus without entering the joint may save the latter. Patients with this type of disease form only a small proportion.

(2) Osseous foci discharging into the joint. There is no evidence that this type, when healed, ever leaves a freely mobile joint.

(3) No visible osseous focus. This group is radiologically synovial. Here the outlook is relatively favourable.

In the later stages these three usually co-exist, so that when the disease has lasted for a time no definite opinion can be given concerning the original site.

The synovial membrane is thickened, grey and translucent and in places gelatinous or excrecentous. Fluid is present in varying amount and adhesions form so that the outlying synovial pockets become localised. Granulations spread under and over the cartilage which being eroded by pressure and friction may become



FIG. 170—Advanced Tuberculous Disease of the Knee Joint



FIG. 171—A severe type of Disease in an Adult with marked Deformity and Sinus Formation

detached leaving the bones exposed. At the same time softening and stretching of the ligaments tend to produce subluxation of the tibia,

which slips backwards and rotates laterally. Inflammation takes place round the joint leading to thickening so that the spindle shaped tumour known as a white swelling is formed.

SYMPTOMS AND SIGNS

At an early stage there is stiffness and swelling. Tenderness and

local increase in heat soon develop in and around the joint and as the disease extends pain and lameness supervene. The combination of muscular atrophy with enlargement of the joint gives an appearance of great swelling. Flexion and subluxation of the tibia are seen in the later stages followed by peri articular abscesses and sinuses.

Swelling The joint being superficial swelling is soon apparent and may be due to synovial thickening or the presence of fluid. Evidence of fluid is obtained by palpation of the supra patellar pouch with the palm of one hand while the other palpates the patella and the pouches on either side of it. When due to synovial thickening the swelling is usually semi elastic.

Limp At first when walking the patient holds the knee moderately flexed to lessen the effect of the body weight but free extension is possible. Later however it is limited.

FIG. 17.—Genu Recurvatum resulting from absence of proper support after Excision of the Knee for Tuberculosis.

Pain, at first moderate later becomes acute. The joint is easily tired and any sudden movement increases the pain. Night cries are common.

Muscular Atrophy and Spasm Atrophy is greater than can be accounted for by disuse and probably arises from some trophic disturbance. Rigidity affects the hamstrings and the biceps acting on the head of the fibula pulls the leg backwards and rotates it laterally.

Shortening The disease by stimulating growth locally may at an early stage cause lengthening but in the more destructive lesions shortening is the rule from retardation of growth and destruction of bone.

DIAGNOSIS

The history may reveal the likelihood of human infection, some previous manifestation of tuberculosis, or some loss of health and vigour. When a child develops a chronic swelling of the knee joint of an indolent character, with flexion and limitation of movement, diagnosis is, as a rule, easy, but there can be no certainty without histological or bacteriological examination.

Calve emphasizes the importance of infection of the regional glands



FIG. 173—Tuberculous Disease of the left Knee Joint

Growth has been activated and there is now actual lengthening of the diseased leg. This is not unusual though not uncommon.

in the groin proved by biopsy as in and in diagnosis. An X-ray picture may be of value in showing signs of early disease especially if comparison be made with the sound knee. Bilateral disease is very rare.

Provisional diagnosis and immediate appropriate treatment is the only safe course in the doubtful synovial type in children.

If all the signs of inflammation in the joint disappear after a few weeks' immobilization Thomas's test is carried out. The immobilization is remitted and if no recurrence follows this freedom further freedom is allowed and the child who has had a toxic arthritis from a throat or other focus is soon without symptoms. But if the condition is tuberculous, warmth and swelling of the joint, and limitation of

In cases of doubtful synovial disease the author carries out a biopsy of the inguinal glands, and if this is negative a diagnostic synovectomy in all patients over nine years of age. Since the treatment under that age will be immobilization in any event a synovectomy is not indicated.

DIFFERENTIAL DIAGNOSIS

Chronic Traumatic Synovitis



FIG. 174.—Tuberculosis of the knee.
Flexion deformity caused by insufficient support
after operative excision.

the knee may be caused by phimosis in young children, but is usually sudden in onset and exaggerated.

Acute Rheumatism is polyarticular, sudden in onset, and responds to salicylates quickly. Cardiac involvement and marked sweating are suggestive. Charcot's joint, hæmophilia and arthritis deformans should present no difficulty.

After injury, enlargement of the joint may persist unduly. In children it is wiser to treat such a case as tuberculosis until the fluid has been examined.

Sub-acute Infective Synovitis may simulate a tuberculous joint, especially when a focus of disease in the bone suddenly bursts into the joint. Aspiration will reveal the nature of the condition.

Gonorrhœal Synovitis From an early stage this is more acute and painful fixation of the joint is very marked, and there is a history of gonococcal infection.

Rickets generally affects more than one limb and there are signs in the gums, teeth and elsewhere. The disease is epiphyseal rather than articular.

Functional affections often simulate tuberculous disease, but positive physical signs are few in number and variable in their manifestations. A reflex stiffness of

PROGNOSIS

The immediate mortality is small—about 10 per cent and the osseous type of lesion bears the greater mortality. Tuberculosis of the knee is not a fatal disease—death comes from the development of the original disease elsewhere.

Hibbs found that of 67 cases of tuberculosis of the knee 7 died



FIG. 13.—Subluxation of the knee from extensive untreated Tuberculous Disease.

from other forms of tubercle and in 13 cases the lesion became quiescent though in 16 of the latter cases the disease became active at a later date. In 16 of his cases he performed a fusion operation and all these patients remained free from symptoms.

The functional result improves in proportion to early diagnosis and efficient treatment. After excision a high proportion—as many as 88 per cent—get a sound bony ankylosis. Cases of bone disease, however, so only if the focus remains extra-articular.

In adults, the best result that can be expected is an ankylosed knee, and this can be secured most quickly and effectively by operation

TREATMENT

As the patients suffer from tuberculosis of which the arthritis is only one manifestation, all need general treatment—preferably in a sanatorium—by physical rest heliotherapy selected diet etc

Local treatment is divided into conservative and operative

Conservative Treatment

At an early stage, when the disease is acute and painful and the joint flexed rapid relief is obtained by traction in the recumbent position. Plasters are fixed to the leg and a Thomas's knee-splint with a knee flexion piece applied. The knee piece permits of the pull being made in the line of the deformity, and as treatment progresses, it can be adjusted daily until full extension is obtained. Great care must be taken to avoid backward displacement of the tibia. Correction of the deformity by wedge plaster of Paris methods, or by "brassage force" should not be carried out. If owing to the onset of ankylosis,



FIG. 170.—Tuberculosis of the knee
The result of operative fixation

the deformity does not respond to traction, operative extension must be considered

When the knee is in a good functional position, that is, just short of complete extension consideration has to be given as in hip joint disease to the ultimate aim of treatment

In the child every attempt should be made to get a movable joint, and as long as there is a possibility of this, traction should be continued. The knee flexion may be removed, a cradle of domette being slung tightly under the knee to obviate any risk of genu recurvatum. In view of the possibility of ankylosis the joint should be very slightly flexed. Traction is applied to the leg either by plaster or domette strapping and circular bandages. Domette slips easily and has to be adjusted daily but is preferable after the more acute stage, as it has no tendency to irritate the skin. The splint is tilted at its lower end or the bed is slightly raised to allow the body weight

to act by counter extension. This method is preferable in the young child, in the presence of sinuses and wherever there is any hope of a mobile knee.

When the bone is seriously involved, ankylosis is the aim. For



FIG. 177.—Tuberculosis of the knee. Genu Recurvatum.
Radiogram of the same case as Fig. 176.

children under nine years of age a plaster of Paris case should be used. It is applied from the toes to the pelvis, and accurately moulded to the leg. This treatment should be continued for at least a year, the plaster case being changed at intervals of a few months if necessary, but it is essential that immobilization be continuous. There should

be no remission of fixation during this period since the disease might start afresh. Plasters which do not include the hip and ankle are useless.

Ambulatory Treatment

When treatment either by traction or by a plaster case has lasted for twelve months the patient may if conditions are favourable be allowed to get up but care must still be taken to protect the joint from weight bearing and movement.

Favourable signs are the absence of pain or other evidence of active disease, good general health with gain in weight and satisfactory evidence from X ray examination.

In the ambulatory stage the patient wears a Thomas's knee-splint which at this stage is fitted with a patten end to make it impossible for the child to walk on his affected leg and a patten is fitted on the foot of the sound limb. If there is any sign of friction on the skin traction is modified and a spreader inserted to prevent chafing. This splint is to be worn night and day for about six months.

At the end of this period when treatment has lasted at least eighteen months the third stage is commenced. The pattens are discarded and the splint converted into a walking caliper. The lateral bars at their distal ends are turned into a box in the heel of the boot care being taken that when standing in this splint the heel of the foot does not quite touch the insole of the boot. This ensures that no weight is brought to bear on the weak joint. The splint is kept in position by the usual thigh and calf straps. It is discarded at night but worn throughout the day for at least two years at the end of which time there should be little risk of recurrence. This long period of immobilization does not lead to fixation in synovial disease. Free and normal movement returns gradually and progressively in the synovial type of disease in children once the knee is set free and if the disease is soundly healed.

During succeeding years it is recommended that the patient be seen at intervals of from three to six months for some years to prevent if possible any deformity or recurrence of the disease.

Operations

In children under fifteen years of age conservative treatment is recommended because its results are reasonably good. Further the soft vascular bone of the epiphysis bends easily even after the operation of arthrodesis so that in any case a splint is necessary for a long period. If there is radiological evidence however, of destruction of cartilage arthrodesis is indicated in patients over nine years of age. The epiphyseal cartilage is sufficiently far from the end of the bone to leave the surgeon a margin for excision without damaging the growth centre. Shortening of the limb does not therefore usually result beyond that due to interference with growth by the tuberculous process. In adults the conditions are different the best that can be hoped for from conservative treatment is ankylosis and this can be

more rapidly and efficiently secured by operation. Operation therefore is recommended unless there is some definite contra indication and indeed should invariably be carried out on the bony focus, in view of the higher mortality from osseous disease treated by immobilization.

Extra-articular osteo-synthesizing operations are impossible in this joint because of its anatomical conformation while the old classical excision of the joint is unjustifiable because of the shortening and the instability that result.

Intra-articular Arthrodesis. The best operation is an arthrodesis between the joint surfaces which is designed to promote bony fusion and to remove all diseased parts. This operation is carried out in adolescents and adults up to 50 but in children only after the age of 15 and when osseous foci are present. It should be delayed however in all cases until the general condition has been improved and the local activity of the disease has been checked by treatment. Contra-indications to the operation in addition to childhood are

- (1) Active phthisis
- (2) Extensive involvement of the shafts of the femur or tibia
- (3) Septic infection of sinuses

The Operation. A tourniquet is used as it makes the operation easier and because with it the patient loses less blood and the likelihood of toxæmia is lessened but it should be removed so that complete hæmostasis may be secured before the nails are inserted. A U shaped incision is made round the knee with the connecting bar of the U across the tibial tubercle. The incision is deepened until the ligamentum patella is exposed. This is cut across above its insertion and the joint is then flexed and opened. The flap is then dissected up and the supra-patellar pouch exposed. The cruciate medial and lateral ligaments are divided and the diseased area exposed. All grossly diseased material is now removed and a synovectomy carried out as completely as possible. A thin shaving of bone is now removed with a small frame saw from the articular surfaces of the tibia and femur so that both retain their normal curves and fit accurately to each other. The cartilaginous surface of the patella is similarly removed. This method allows easy adjustment of the angle of the arthrodesis. The joint is then extended to 170° and the ends of the bones accurately adjusted.

In all cases it is better to retain apposition of the bones by the use of two excision pins or bone pins. These are inserted through the skin on both sides of the tibia below the joint and are easily removed in about six weeks. No drain is inserted.

AFTER TREATMENT

A plaster of Paris cast is applied from the toes to the crest of the ilium. The knee joint is fixed at an angle of 170° which is just short

of full extension. A window may be cut over the incision and through it the stitches and nails removed. Union should be complete in four months when the plaster may be removed and a Thomas's walking caliper substituted. This is worn for from six to nine months in the case of an adult or until the X rays show sound union but when the patient is a child it is necessary until bone growth has ceased otherwise a flexion deformity may occur at the epiphysis.

Good bony ankylosis occurs in 88 per cent of cases according to Henderson of the Mayo Clinic. Failure to secure union may be due to operating while the disease is active or the patient's general condition too poor to active tuberculosis elsewhere to pyogenic infection from a sinus or to ineffective immobilization. Amputation is only rarely indicated. It is carried out when either the patient or the limb has little prospect of recovery and so is done in the very old the very septic the very ill and in those cases where the bone destruction is too extensive for arthrodesis.

TUBERCULOSIS OF THE ANKLE

The ankle is the site of infection in about 10 to 15 per cent of all tuberculous joint affections. In over 4 000 cases admitted to East Fortune Sanatorium the ankle was involved in 26 per cent of the cases of bone or joint lesions. The joint is resistant to treatment especially in adults owing to the weight it has to support its complex character and the free communications of its synovial spaces.

PATHOLOGY

In early cases in children at least the disease may be seen to be in one of three groups as is common in other joints.

(a) Extra articular disease

(b) Synovial disease

(c) Intra articular disease

(a) The extra articular type may be in the neighbouring soft tissues in the bony structure as for example the bone abscess seen often in the calcaneus but also in the talus and cuboid.

(b) In the synovial type there is generalized decalcification of the bones with synovial thickening.

(c) The intra articular type forms the largest group and the ankle joint itself is the usual site though other smaller joints may appear to be the initial site.

Sinus formation occurs in the great majority of cases though here this does not appear to have the same malign influence that it has in other joints and a sound though fibrous ankylosis usually results in children.

SYMPTOMS AND SIGNS

Lump and pain are the earliest symptoms. The pain is more acute in those lesions that spread from the bone, being intensified by pressure on the calcaneus, either by increased plantar flexion, or by lateral compression of the bone. The first deformity is dorsiflexion, to relieve tension on the talus but later, with the progress of the disease plantar flexion and equino valgus deformities develop both of which relieve the pressure of the weight of the body on the foot. The patient then walks stiffly, and on his toes. Swelling is evident in front of the joint in bone disease, and round the malleoli in synovial disease. Local heat and redness may be present, and there is the usual limitation of movement from muscular spasm. In the later stages, abscesses and sinuses are common. The radiogram shows rarefaction and foci of disease in the talus.

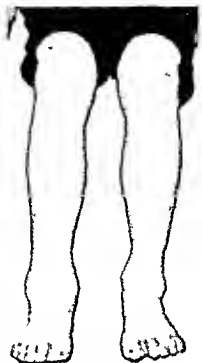


FIG. 173.—Tuberculosis of the Ankle

The clinical appearance of synovial disease in the ankle-joint.

DIAGNOSIS

A chronic mono articular arthritis with limitation of movement, pain and tenderness and evening pyrexia is probably tuberculous. The osteoporosis seen on X ray examination is characteristic. Biopsy is not carried out as it is apt to produce sinus formation.



FIG. 171.—Tuberculosis of the Ankle

Advanced disease with sinus formation, necessitating amputation.

DIFFERENTIAL DIAGNOSIS

Chronic Traumatic Synovitis often results from a severe sprain, but the tenderness is usually localized over the ligaments. The swelling is a general puffiness and the X ray film is negative.

Arthritis Deformans. As a rule, other joints are affected and there is usually less pain and in absence of muscular spasm. The radiogram is helpful there being a mottling of the bones. Diagnosis, however, may be difficult.

Fracture of the Calcaneus has certain points of resemblance, but the radiogram removes any difficulty

PROGNOSIS

W R D Mitchell has pointed out in an interesting monograph the extraordinary difference in the prognosis in children and in adults. He says that it is uniformly good in children and equally bad in adults and his figures appear to bear this out. Over 95 per cent of children adequately treated and over 80 per cent not so well treated give good results. A good result is where the disease is arrested and no disability results. In adults only 27 per cent were able to go back to work with



FIG 180—Fungating Ulcer arising from Synovial Disease of the Ankle

the disease cured and he believes that there is no guarantee that these cures are permanent

TREATMENT

Following on Mitchell's convincing paper with which the author is in substantial agreement the treatment is somewhat different in the child under 17 and in the adult

(A) In Children

The treatment is entirely conservative locally along with the very important general treatment already laid down

Immobilization This is carried out fully and continuously and during the greater part of it the child should be in bed

(a) If there are no sinuses a plaster of Paris case is applied from above the knee to the toes. It should be fairly light and moulded to the bony prominences. It has the disadvantages of hiding the formation of abscesses and of preventing local heliotherapy but on the other hand it fixes the joint as no other method does. However if an abscess does form it won't suffer by being enclosed and if profuse it will soon make its presence known. The foot is placed at a right angle care being taken to avoid eversion. This casing may be removed

in from three to four months to permit of X ray examination after which it is reapplied for a similar period.

(b) If sinuses are present or expected a right angled foot splint of the crab type or a celluloid moulded case is used. The foot is retained in the splint with encircling bands of adhesive plaster and a firm bandage applied over all to improve the immobilization.

It is inadvisable to allow walking at this stage as the distal foot and ankle readily become oedematous.

At the end of about eight months or when recalcification is complete as judged by a series of X rays the splint may be substituted in those cases where plaster of Paris was in use. This allows the minimum of

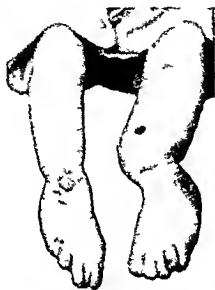


FIG. 11.—Bilateral Ankle Disease of long standing and with little active disease.



FIG. 12.—X ray of Bilateral Ankle Disease.

movement and permits of careful observation. After four months use the splint is discarded entirely at night a short walking caliper being worn during the day. This if properly applied relieves the foot and ankle of a certain amount of weight bearing. Careful fitting is essential. The upper cuff of the caliper must be smoothly round the leg immediately below the head of the fibula and the medial condyle of the tibia and when fitted into the shoe the patient's heel must be clear of the insole. If attention is directed to these two points the ankle will be relieved of the weight of the body which will now be brought to bear on the head of the fibula and the condyle of the tibia. The short walking caliper is worn for a further period of at least six months.

The above description applies to the treatment of a straightforward

case The duration of each stage, however, varies greatly The onset of pain, an increase of swelling, or of limitation of movement, fever, or loss of weight, may necessitate delay in the passage from one stage to another Should a sinus develop, as it frequently does, it is not interfered with surgically unless a definite sequestrum is present In such a case the sequestrum is removed with the least possible trauma Otherwise the sinus is kept covered with sterile gauze changed sufficiently frequently to prevent secondary infection

Traction methods, from their difficulty of application, have not been popular, for the relief of pain they are not superior to efficient fixation

There appears to be no place for operative treatment in the ankle of a child

(B) *In Adults*

The result of treatment in adults is bad probably because patients won't stand the necessarily prolonged immobilization and inactivity when their only complaint is a "sore ankle" and treatment therefore often becomes a compromise

In an uncomplicated case in an adult conservative treatment is continued for six months and the case is reviewed at the end of that time and unless there is a marked improvement more radical measures are suggested If the disease has not progressed or is improving, then immobilization is continued In the majority of cases in adults, however the disease has extended in spite of treatment, and amputation is advocated The disease is shortened, metastatic involvements from this area are prevented, a long illness is cut short, and with the modern type of prosthesis the patient is little handicapped by losing his limb Mitchell believes that there is little justification for the less radical procedures such as scraping, excision, astraglectomy, and arthrodesis in this joint

TUBERCULOUS DISEASE OF THE TARSUS

As in the ankle joint, the talus is frequently the seat of the primary disease, it may, however originate in the calcaneus The mid tarsal joint is most frequently involved Two varieties are described In one the disease starts near the surface of the bone and spreads rapidly to the neighbouring joints, while in the other, which is frequently seen in the calcaneus the disease is deeply seated in the substance of the bone and is difficult to diagnose from a Brodie's abscess Endarteritis of the nutrient vessel is common

Symptoms

Pain is an early symptom, but is usually less severe than in disease of the ankle joint Inversion and eversion are limited when the posterior bones are infected, while in cases of more distal infection, movements at the mid tarsal joints of the foot are also restricted Swell

ing is evident on the dorsum of the foot over the region of the disease. A limp and an equino valgoid deformity complete the picture.

An X ray examination shows general osteoporosis and often a focus of disease in one of the bones.

DIAGNOSIS

A diagnosis is made from the swelling limp deformity and X ray appearances. Köhler's epiphysitis of the navicular has to be considered in the differential diagnosis.



FIG. 183. Tuberculous Disease of the Talus with a Central Sequestrum.

TREATMENT

Treatment is similar to that carried out in disease of the ankle joint but operation is more frequently called for usually that of sequestrectomy.

TUBERCULOSIS OF THE SACRO ILIAC JOINT

The sacro iliac articulation is a true joint with all the usual joint structures and therefore subject to all joint diseases. It is rarely

infected with tuberculosis in children but at the termination of the growth period the disease is more common and is not infrequently bilateral. Of the bone and joint lesions admitted to East Fortune Sanatorium 3 per cent involved the sacro iliac joint and slightly less than half of these were complicated by lesions at other sites. All but one of the cases occurred after the age of 15.

The disease may originate in the lateral mass of the sacrum or may spread thence from the lumbar vertebrae. It is also seen not infrequently in association with a tuberculous hip. The synovial membrane then becomes infected and finally by extension the ilium. *Abscess formation* is the rule and usually occurs early in the disease often as the first sign though it is likely of course, that the disease has been of a latent or symptomless character in such cases. According to Elmslie it is rarely that pain and abscess are coincident as once an abscess is diagnosed it has broken through its confining walls and relieved the tension that causes the pain.

In the great majority of cases the abscess is situated over the posterior aspect of the joint much less commonly in other regions such as the groin or gluteal region. It is rare in the pelvis. In a considerable number of cases a sinus results from this collection of pus.

SYMPTOMS

The onset is frequently insidious and an abscess is often the earliest indication. Usually pain and tenderness are the first symptoms.

Pain is felt most commonly as a sciatica or in the hip or lumbar region or over the joint. It is increased by movement and is worse at night owing to the increased strain on the pelvic joint when the lordotic curve is obliterated. The pain is increased by the strain of sitting for long periods stair climbing or stooping. In women it is aggravated at the menstrual periods. It is referred to the sacrum or the back of the thigh and is increased by jars sudden turns as in bed and often by coughing or laughing. In sacro iliac disease suggestive attitudes are frequently observed. In the standing position the body is inclined away from the diseased side and on rising the hands are used to support the spine and at the same time to keep it rigid. Only short steps are possible in walking owing to the accompanying spasm of the hamstrings.

Motion is limited in various ways. Forward bending with straight knees is limited but with the knees flexed as in sitting the extent of flexion is increased—in this respect differing from what is found in lumbar disease. Extension and lateral flexion are also limited. It will be found that straight leg bending in the recumbent position is limited and usually pain is produced when the movement is attempted on either side. This is known as Goldthwaite's sign.

DIAGNOSIS

Albee says that the following symptom complex is pathognomonic of an affection of the sacro iliac joint

- 1 Pain at the joint on turning over while in the recumbent position
- 2 Discomfort when lying on the back
- 3 Pain on sitting on the affected side relieved by sitting on the opposite buttock
- 4 Pain in the joint on forward bending
- 5 Pain on pressure over the joint
- 6 Listing of the spine to the opposite side
- 7 Positive Goldthwaite's sign

The conditions likely to be confused with sacro iliac disease are arthritis of the hip disease of the lumbar vertebrae lumbago and sciatica. X rays are not particularly helpful in the early stages but in time show erosion of the joint line foci in the ilium or sacrum or some alteration in the joint line but unlike most tuberculous joints very rarely decalcification.

The prognosis is not good for adults though Seddon has pointed out that as an isolated uncomplicated lesion the mortality rate may be under 10 per cent. A sinus however he adds increases the rate to 25 per cent while the presence of an associated tuberculous lesion raises it to 55 per cent.

TREATMENT

Conservative treatment follows the same lines as that of Pott's disease of the lumbar vertebrae. Recumbency with adequate protection and immobilization of the joint are indicated these can best be carried out by a double spica of plaster of Paris extending from below the nipples to below both knees. The pelvic part of the plaster should be firmly moulded to the contour of the pelvis and retained in place for from twelve to fifteen months. Thereafter prolonged protection of the joint is necessary. Most cases heal by bone fusion.

When sinuses have formed a Thomas's leather abduction frame is valuable.

Operations

In some cases an attempt is made to shorten the length of treatment by an operative fusion. It is very doubtful whether the operation achieves this purpose and indeed Seddon has stated that the gain is only about one month in that the average treatment conservatively is eighteen months and by operation seventeen months. Operation may be of use however where a stable bone fusion is slow or where the disease has healed by fibrous union. It is of course contra indicated in the presence of a sinus and is not advisable in children or where there are other lesions though if there is a lesion in the lower lumbar vertebrae a double spinal fusion operation may be considered.

Methods of arthrodesing this joint are numerous. Albee, Smith, Petersen, Verrall, and Gaenslen, have each described an operation. Two of these are described here: the extra-articular method of Albee and Smith-Petersen's one which, though intra-articular, appears to give very satisfactory results. Whatever operation is carried out, it should like all other similar operations be reserved until any acute features have settled down and healing has started.

An anterior shell is made for the patient some time before and he gets an opportunity of becoming accustomed to the prone position.

The best incision for exposure is that of Smith-Petersen. It is a semilunar one along the posterior two thirds of the iliac crest, curving around the posterior iliac spine, then running parallel with the fibres of the gluteus maximus for a distance of 2 to 3 inches.

1 Smith-Petersen's Operation This is carried out as described on p. 609. Should any tuberculous material be met with, an attempt at local eradication of the disease is made.

2 Albee's Operation for Combined Sacro-iliac and Low-lumbar Disease The posterior superior spine, the wing of the ilium, and the first spinous process of the sacrum are reached by a curved incision. The spinous processes of the last one or two lumbar vertebrae are split with their attached ligaments by the author's (Albee's) thin wide osteotome, forming a gutter to receive the ends of the graft. A cleft is made in the posterior wing of the ilium by driving a thin osteotome $\frac{1}{2}$ inch in width into it just anterior and medial to its posterior superior spine and in a direction laterally from

within outward. The lateral graft, which is later secured, is formed with a wedge end to be driven into this cleft, the other end being joined by a carpenter's half mortise to the spinal graft.

If practicable, a surface of the sacrum is denuded to furnish additional contact with the graft. The wound is packed with a saline compress and with the patient still in the prone position, the leg is flexed and a graft of sufficient length removed from the crest of the tibia by the motor saw to furnish

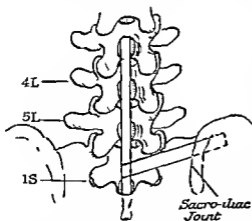


FIG. 184.—Tuberculosis of the Sacro-iliac Joint.

Albee's operation for fusing the sacro-iliac and lumbosacral joints.

material for the spinal graft and the lateral bridge to the ilium. The width of the graft should be three times the thickness of the cortex. The thickness should include the whole cortex, periosteum, endosteum, and a small amount of the adhering marrow. The spinal graft is

placed in its prepared bed and the ligaments are drawn over it by interrupted sutures of medium kangaroo tendon.

Before the kangaroo tendon sutures are drawn over the lower end of the spinal graft a segment is removed from its uppermost surface and into it one end of the lateral graft is half mortised and the other wedge shaped end is driven into the cleft in the hum prepared for its reception.

The skin wound is closed and the patient placed on the back on a fracture bed for a period of not less than six weeks. There should be no necessity for further treatment. (*Albee's Orthopaedic Surgery* p 441)

TUBERCULOSIS OF THE SHOULDER JOINT

Tuberculosis of the shoulder joint is rare particularly in children. Shropshire Orthopaedic Hospital reports 27 out of a total of 2922 cases of tuberculous disease of the spine and joints a percentage of less than 1.

PATHOLOGY

The disease originates as a rule in the head of the humerus. The commoner form is the so called *caries sicca* a dry atrophic form with much wasting of muscle pain and limitation of movement but no abscess.

The other form is the florid type with much thickening of the synovial membrane. The head becomes eroded its place being filled by fibronyxomatous and granulation tissue. The muscles contract and pull the head hard against the glenoid which also becomes eroded. Finally the whole joint becomes destroyed and filled with pus. In many cases the apex of the adjacent lung is infected either primarily or secondarily.

SYMPTOMS AND SIGNS

An insidious onset is characteristic doubtless because this is not a weight-bearing joint and because the early limitation of movement—abduction—is to some extent masked by the mobility of the scapula on the chest wall. In the early stage there is dull aching in the front of the joint and at the insertion of the deltoid. This may be referred to the elbow and forearm.

Limitation of abduction and of lateral rotation are marked the joint swells the muscles atrophy and soon it is necessary to support the arm in a sling. An abscess may form at a later stage and rupture through the capsule anteriorly pointing in front of or behind the insertion of the deltoid. Subcoracoid dislocation from disintegration of the joint and destruction of the ligaments may follow. A radiogram shows at first an irregular outline of the head of the humerus with erosion of the joint line. Later the destruction of bone is obvious.

DIFFERENTIAL DIAGNOSIS

Arthritis Deformans is polyarticular often preceded by creaking and stiffness and only at a late stage is the pain marked. A radiogram gives a characteristic picture.

Sarcoma affects the humerus itself and does not involve the joint. The swelling is distal to the joint. Pain is not as a rule severe and the joint movements are not greatly limited.

Subdeltoid Bursitis. Antero posterior movements are free. The wasting is not a prominent feature and the pain is less severe than in a tuberculous joint.

PROGNOSIS

The disease in this position is very resistant to treatment and if recovery takes place adduction with ankylosis usually results. The death rate is higher than in joints of the lower extremity owing to the high incidence of pulmonary disease.

TREATMENT

General treatment including hospitalization is just as necessary in this case as in other joints. The patient should be completely rested in bed at any rate during the early stages.

Local treatment is by immobilization by means of a plaster case enclosing the arm from the wrist upwards the chest and body. It is debatable whether the chest piece should extend down to sit on the iliac crests since this is very uncomfortable and probably efficiency is obtained by a somewhat shorter jacket stopping short of the crest. If the scapula is movable on the chest wall the shoulder is abducted to an angle of 70 degrees or a little more in a child the elbow being on the same plane as the anterior chest-wall and the humerus rotated laterally so that the forearm is at an angle of 15 degrees with the horizontal. This method provides efficient fixation is



FIG. 185.—Tuberculosis of the Shoulder
Illustration for treatment of either Shoulder
or Elbow Disease

Note the optimum functional position

comfortable lessens pain since it takes the weight of the arm off the joint structures, and when ankylosis takes place leaves a useful arm.

Operations

Should the disease be mild in degree the plaster will remain on for about one year although it may be necessary in a growing child to change it during this period. Thereafter an abduction splint will be used and if possible a return to mobility encouraged.

Where the disease is osseous however ankylosis is the aim and

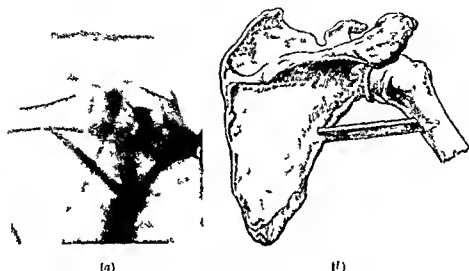


FIG. 156—Arthrodesis of the shoulder by the extra-articular method of Britain. A somewhat modified type of graft is shown. The scapula in contact with the graft should be deprived of periosteum and bare bone exposed.

this is more likely to be achieved by some form of operative arthrodesis. Operation will be carried out at an earlier period in adults and more reluctantly in children. In both cases the activity of the disease should have ceased and the resistance of the patient raised to the optimum degree. Operations are contra-indicated in very active lesions with open sinuses and in old quiescent lesions that have caused ankylosis and resulted in extreme muscular atrophy and usually in children.

In adults some osteosynthesizing operation is indicated in most cases in view of the long duration of conservative treatment and the possibility of spread of the disease to the lung. Complete ankylosis is secured much more quickly by this than by any other method and pain is relieved.

Extra-articular Arthrodesis

(1) High Operation. The ordinary interior exposure of the joint is used but prolonged upwards over the shoulder farther than usual

to expose the acromion. The deltoid is retracted laterally from the pectoralis major avoiding the cephalic vein and is stripped off the clavicle and the acromion. The acromion is now denuded of periosteum on its upper and lower surfaces and a cleft made between the great tuberosity and the humerus levering the tuberosity off the head in an outward direction. The acromion and the outer end of the clavicle are now snipped with bone forceps so that when the humerus is abducted the acromion can be levered and bent into the cleft in the humerus. The tuberosity may be pinned in position by a peg going through the tuberosity, acromion and humeral head. The optimum position for arthrodesis is assured by a plaster jacket as used in the conservative method.

(2) **The Low Operation of Britain.** This is an extra articular operation carried out by bridging the space between the scapula and the humerus through a posterior incision.

A tibial graft is cut in the shape of an arrow—one end pointed and the other bifurcated or forked. The length varies with the patient but it may be cut generously to about 5 or 6 inches since if it is too long it can be shortened at the pointed end. The patient lies on his face with the affected arm hanging down over the side of the table. This produces the usual position of the shoulder joint for arthrodesis and is an easy position for the operation. Britain described his operation thus:

An incision 7 inches long is made starting at the posterior margin of the deltoid passing up over the axilla and proceeding down the axillary border of the scapula to 1 inch from its inferior angle. The lower part of the incision may be started first and the posterior aspect of the axillary border of the scapula cut directly down to bone. The teres major and minor are identified and an incision is made through the latter down to the axillary border of the scapula which is cleared with bone elevators. The circumflex scapular artery will be seen and should be divided between forceps. The divided teres minor will fall forward and expose the axillary border satisfactorily. The long head of the triceps will be seen arising from below the glenoid. This should be defined and the interval between it and the posterior border of the deltoid defined and widened. In the floor of this interval will be seen the lateral head of the triceps arising from the humerus and an incision is made through this and the humerus exposed. Two inches of the humerus should be cleared and bone elevators passed round the bone. Care should be taken not to prolong this incision too proximally as the circumflex artery may be severed. The circumflex nerve is not so important as the shoulder is being fused. A drill hole is now made $\frac{1}{2}$ to 1 inch in diameter and an electric drill may be used for this. The aperture is widened by gouges until it is 1 inch in length and $\frac{1}{2}$ inch in breadth. Precise measurements are now taken of the distance

the graft has to traverse and a suitable area on the axillary border of the scapula decided upon. A notch is made in this to receive the graft and this notch should be $\frac{1}{2}$ inch in breadth and 1 inch in depth. Fracturing the blade of the scapula is not a serious error as more new bone will be thrown out by this. At the same time it should be avoided as it may make the attachment of the graft insecure. The point of the arrow graft is inserted into the humerus first and then by abducting the arm the graft can be carefully inserted into position so that the limbs fall into the notch in the scapula and grasp the bone. The more difficult this is to do the firmer will the graft be secured. It may be found necessary to divide the long head of the triceps and if so it should be divided above its nerve supply and sutured in whichever position it lies best over the graft is possible so that the latter is covered by muscle. The *teres minor* is sutured and the wound closed in the usual way. The plaster is then completed by long slabs on the arm and across the back and chest with the patient still lying on his side.

The author has carried out this operation several times now and heartily endorses the sound mechanical principles and from his results warmly advocates the operation.

After being worn for three to six months the plaster case is removed and an X-ray taken. When fusion is complete in abduction splint is substituted and the scapular muscles exercised and re-educated.

See also Chapter XXV for other methods of arthrodesis.

TUBERCULOSIS OF THE ELBOW JOINT

The disease is met with more frequently in this joint than in the shoulder or wrist. It is more common in adults than in children. In 1000 cases admitted to East Fortune Sanatorium the elbow was involved in 18 per cent of the cases of bone and joint lesions.

PATHOLOGY

Opinion is divided as to the primary site of the disease. It is commonly synovial but in some cases a bone focus in the ulna or in the radius appears to be the original seat, the lateral condyle of the humerus coming next in order of frequency. The disease may be so well established when the patient is seen for the first time that certainty on this point is impossible. The head of the radius is rarely attacked.

SYMPTOMS

Pain aggravated by movement is at first confined to the joint. At a later stage it may extend to the forearm. Swelling is noted on the back of the elbow on both sides of the olecranon and the bony

prominences are obliterated. Muscular spasm sets in and movement is limited. At first only the extremes of flexion and extension are affected but later the joint becomes stiff at a mid position with the forearm fixed midway between pronation and supination. Muscular wasting is pronounced and as in the knee joint this may cause an exaggerated impression of the degree of swelling. Local heat varies



FIG 18^a—Tuberculosis of the Elbow Joint

with the activity of the disease. When an abscess forms it points at the lateral side of the lateral condyle. An X ray picture shows osteoporosis erosion of the joint surfaces or possibly a focus of disease in the bone.

DIFFERENTIAL DIAGNOSIS

Arthritis deformans and Charcot's disease have to be kept in mind in arriving at a diagnosis but any insidious arthritis must be regarded with suspicion since tubercle is the most likely diagnosis.

PROGNOSIS

With early and efficient treatment the outlook is hopeful. A useful joint should result in the majority of patients.

TREATMENT

Tuberculosis of the elbow joint in children is best treated by conservative measures. The joint is placed at rest in the position that will be most useful should ankylosis ensue which in most cases is flexion at a little less than a right angle. In young children modified fixation may be carried out by a collar and cuff method. A wristlet of soft leather is applied to the wrist and a leather collar to the neck, the two being fixed together by lacing. This method of treatment has the additional advantage of reducing the deformity when the angle of flexion is too obtuse. The neck is bent forward thus fixing the collar to the cuff and the patient can then free himself by flexing the forearm further and so reducing the deformity. At the next visit the slack is taken up and the deformity is in this way finally reduced.

The ideal method of treatment would be the application of a shoulder plaster reaching to the fingers which would ensure immobilization. This method is rarely employed and an example is thus provided of a joint being treated by inefficient immobilization. The writer uses the collar and cuff method of reducing deformity and when the position is corrected if age permits a plaster of Paris case otherwise a celluloid splint is applied. When the patient feels his arm well and has no pain he is allowed to use a sling. The sling is lengthened gradually and if in a few days the arm can be lifted to the point from which it started recovery is presumed and the arm may be allowed greater freedom. This is a good test of recovery of the joint. Usually fixation is required for about eighteen months.

Operative Treatment

In some cases it may be possible to remove small foci of disease from the olecranon or adjoining bones before the joint is involved. Excision of the elbow joint for tuberculous disease is rarely carried out as a stiff joint is liable to result but if the disease progresses in spite of conservative treatment it may be necessary to excise the joint and afterwards to perform arthrodesis.

This is carried out by Lamkenbeck's method through a median posterior incision the nerves being carefully avoided. The skin flaps are reflected forwards and the triceps stripped upwards after crasing its insertion into the olecranon. The forearm muscles are freed from the humerus and the joint thoroughly opened up. All the diseased synovial membrane and foci in bone are cleared out and the olecranon and lower articular ends of the humerus excised. Arthrodesis is then carried out after the manner advocated by the writer (see Chapter XIX). The remains of the lower end of the humerus are fixed into a complete square with an ordinary rough file. The desirable position for ankylosis

has already been determined and with care this can usually be secured by dealing with the forearm bones. A square hole is made with the saw between and as near as possible to the ends of the two bones so that the humerus already prepared may be fitted into it. A small fine frame saw with detachable blade is used. When the humerus is fitted into the square aperture the three bones are clamped together with wire which may be permanent or not according to the presence or absence of secondary infection. The wire is twisted tight in front of the joint. Plaster is applied as for a shoulder case and retained for three months. A window may be cut in the plaster to allow dressing. A good firm ankylosis usually results.

TUBERCULOSIS OF THE WRIST

Tuberculosis rarely affects the wrist in childhood. Of 3015 cases of tuberculous joint disease treated in the Hospital for Ruptured and Crippled 98 were of the upper extremity and only 4 of these were affections of the wrist. In adults it is not so rare.

The disease though it may be synovial in origin usually starts in the bone the commonest site for the primary focus being in the lower end of the radius or the os capitatum. Because of the intricate arrangement of the synovial membrane and the small size of the bones dissemination is rapid. The disease frequently spreads to the flexor synovial sheaths causing a fibromyxomatous degeneration. Abscesses and sinuses are common sequelæ.

The usual symptoms are swelling deformity pain and limitation of movement. Physical signs are soon evident owing to the superficial character of the joint which also makes examination easy. Pain is an early symptom. At first it is felt at the site of the disease but later becomes general throughout the joint. Palmar flexion is the usual deformity. The movements at the wrist joint and frequently at the inferior radio ulnar joint are limited in all directions. Abscesses are superficial and they usually break down and form sinuses.

Owing to the superficial nature of the joint diagnosis is not difficult.

The condition is very resistant to treatment particularly in adults in whom it is often complicated by lung disease.

TREATMENT

Conservative Treatment The wrist should be fixed in the dorsiflexed position in a plaster of Paris case extending from the metacarpophalangeal joints which are flexed to 30 degrees to above the elbow. The thumb and fingers should be accurately opposed. It is imperative to maintain dorsiflexion as ankylosis results in the majority of cases and this position gives the optimum of strength and usefulness. The plaster treatment should be continued for at least eighteen months, for a shorter period will inevitably be followed by recurrence. The plaster should fit accurately and be skin tight or over stockinette at the

most After the plaster is removed, a leather lacing wristlet is used for six months to protect the joint for a further period

In the presence of sinuses a 'crab' cock up splint may be used, or a plaster of Paris splint with windows cut to allow dressing of the sinuses

Operations

In view of the multilocular character of the synovial pockets, the difficulties in curing the disease the possibility of extension to the lungs and in general the bad prognosis the tendency is toward operative treatment Curetting and excision are not satisfactory the former because it is so often incomplete, the latter because it tends to be too extensive The one does not eradicate the disease while the other although it removes the disease too often leaves the wrist flail and the limb functionally incapacitated

Arthrodesis This is the operation of choice if it is performed before the formation of sinuses with their inevitable secondary infection It is carried out after the method of Albee and is to some extent extra articular An ankylosis is produced between the metacarpals and the radius by inserting a bridge of bone Consequently absolute immobility of the wrist results and as the bed in the radius is made deeper in its proximal part than its distal the wrist is ankylosed in the dorsiflexed position

After a dorsal incision has been made the carpus is exposed and periosteum incised and elevated over the distal extremity of the radius and third metacarpal bone With the motor saw a gutter is prepared measurements of which are taken with a flexible probe and a bone graft removed from the tibia and inserted in the prepared bed the graft is held in place by kangaroo tendon around the metacarpal bone and by the same material through drill holes in the radius After suturing periosteum and skin, the wound is dressed and the forearm, from fingers to elbow immobilized in plaster of Paris bandages for at least three months" (Albee's *Orthopaedic Surgery*, p 277)

Brittain cuts a bail graft half an inch longer than the bed and half an inch wide and inserts it, not flatly but on its edge Its shape allows it to be firmly slotted into the bed between the radius and the third metacarpal when traction is put on the wrist The wrist is completely locked in position by the graft (see plate 817)

CHAPTER VII

NON TUBERCULOUS AFFECTIONS OF JOINTS

PYOGENIC ARTHRITIS

Purulent infections of a joint cavity are due to the introduction of pyogenic organisms. The commonest of these are the cocci, the staphylococci being the most frequent although various types of streptococci, pneumococci, gonococci and meningococci also occur. More rarely arthritis may result from the invasion by the bacillus typhosus. The joint reacts by exuding fluid which may later become purulent; the organisms may be cultured from the pus but in non purulent cases there may be no growth on culture. The latter type of case is due to the circulation of toxins or of bacteria of considerably limited virulence.

The disease is sometimes polyarticular but in many cases has been superimposed on a wound and is therefore confined to one joint.

The Routes of Infection. The organisms gain entrance as they do in acute osteomyelitis. Thus the joint may be infected by the direct implantation of bacteria through a puncture wound by the direct extension of infection from a compound fracture or an inflamed bone or the process may result from a hæmatogenous infection, the primary focus being situated in the genito-urinary tract, the respiratory tract, the intestinal tract, the teeth or the tonsils. Occasionally no primary source can be discovered. Acute arthritis may also occur in the course of acute infectious diseases like typhoid fever, pneumonia, influenza and scarlet fever and in this event the responsible organisms are the ordinary pyogenic cocci or the specific bacteria causing the febrile condition. Occasionally the joint manifestations are the result not of the presence of actual organisms in the joint but of toxins.

PATHOLOGY

The reaction of the joint is determined by the virulence of the organisms and the resistance of the individual. In any case there is an exudation of fluid into the synovial cavity which will be serous, sero-purulent or frankly purulent according to the gravity of the disease.

1 The Serous Type. The joint is distended with clear serous fluid and is the site of a mild inflammatory congestion with dilatation of

the vessels of the synovial membrane and capsule. The effusion may subside gradually without further trouble or it may subside and later recur or it may eventually become sero purulent or actually purulent.

2 The Sero-fibrinous Arthritis Here the synovial membrane is not merely congested but actually inflamed so that the joint aspect is covered with a sero fibrinous exudate and the cavity filled with a cloudy fluid containing a large number of polymorphs and a few large mononuclear cells. Organisms are present in the joint fluid in the early stages. There is usually in addition some peri articular inflammation and since adhesions are particularly liable to follow the ultimate degree of function of the joint depends on the amount of scar tissue and the number of adhesions.

3 Purulent Arthritis In the most severe type of acute arthritis the whole joint and its surrounding structures are quickly involved. There is a considerable exudate of pus in the joint cavity containing large numbers of polymorphs bacteria red blood corpuscles and fibrin. The capsule and synovial membrane are infiltrated with leucocytes and engorged and there may be small areas of focal necrosis or fatty degeneration. The destruction eventually spreads to the articular cartilage which may become completely detached to lie free in the joint cavity in a pool of pus. The bone is thus exposed and if the disease is very acute osteomyelitis may arise with its sequelae suppuration necrosis and sequestration. The intra articular ligaments may be destroyed as the tension of the exudate rises and finally the capsule may be perforated the pus escaping from the joint to form an extra articular or peri articular abscess.

The end result depends on the stage at which treatment is instituted and if treatment has been started early a surprising amount of function may be preserved. In the majority of cases however there is gross disorganization of the joint which is left crippled by adhesions and ankylosis. When there has been great interference with the joint structure the joint surfaces at a later date are liable to be displaced.

SYMPTOMS

In the absence of suppuration—that is in the serous and sero fibrinous types—the symptoms resemble those of acute rheumatism. Movement either active or passive is practically impossible because of the pain but usually only one joint is involved in sharp contrast to acute rheumatism. Chronic cases are similar to and perhaps identical with rheumatoid forms of arthritis and many joints may from time to time undergo attacks of pain swelling and stiffness. The adjacent muscles are also implicated and undergo fibrous changes so that they become weak and stiff. The repeated distension so relaxes the ligaments that the joint becomes more and more unstable and insecure and the slightest movement then causes extreme pain. Acute exacerbations occur again and again and may be accompanied by a mild pyrexia. If the disease

progresses the affected joints sooner or later become dislocated and serious deformities result

(a) **The Serous Type (Acute Synovitis)** Acute synovitis is evidenced by a tense painful swelling of the joint. In superficial joints such as the knee the bony outline may be completely obliterated. The joint feels hot, and it is usually kept in a position of slight flexion by muscular spasm and any attempt to move it is attended with severe pain. The temperature is raised and there is usually a high leucocytosis. If the joint is aspirated at this stage a clear exudate will be obtained with a low sugar content.



FIG. 188—Acute Arthritis of the Hip Joint

(b) **The Sero-fibrinous Type** This is a later stage of the serous type and is a much more serious condition. The joint is exquisitely tender, fever is high, and night pains occur from loss of muscular control.

(c) **The Suppurative Type** In the early stage of the suppurative type when the disease is limited to the synovial cavity the symptoms differ little from those of acute synovitis. The patient however is more apprehensive, he feels extremely ill, and the joint is more painful. The limb wastes rapidly and the temperature is high.

TREATMENT

When arthritis is suspected the joint should in each case be aspirated

for diagnostic purposes any fluid withdrawn being submitted to histological and bacteriological examination

Acute Synovitis The patient is confined to bed and the joint immobilized. When the symptoms are very severe a weight extension is of great value. There is less danger in thus immobilizing the joint until the infection has subsided than in allowing movement which merely disseminates or prolongs the inflammatory process. During this period careful radiological examination should be carried out to exclude the possibility of osteomyelitis which is often associated with a reactionary synovitis.

The aspiration is repeated as required and so long as the fluid remains clear and serous no further treatment is necessary. As the amount of fluid diminishes gradual movement may be commenced to lessen the formation of adhesions.

Penicillin should not be introduced into the joint prophylactically at this stage because gram negative organisms may also be introduced accidentally.

The Sero fibrinous Type. When the fluid has become slightly turbid the joint should be aspirated and penicillin solution 500 units per c.c. should be injected into the joint to the amount of half the volume aspirated. If the organism is not penicillin sensitive simultaneous aspiration and irrigation can be tried. Two needles are inserted into the joint and saline mercurochrome or ether used as the irrigating medium.

Purulent Aspirations. When aspiration reveals the presence of frank pus penicillin replacement may yet be successful but if the pus is still thick thereafter on re-aspiration 48 hours later the joint should be opened and irrigated with penicillin solution. The capsule should then be closed securely round one or two fine rubber catheters leading into the joint and the skin loosely approximated. Penicillin is instilled into the joint 5-10 c.c. twice daily after aspiration for three days and the tubes then removed. By these means a movable joint may be achieved.

If the arthritis is unsuitable for penicillin treatment the joint should be opened and irrigated the capsule repaired and a drain inserted as far as the suture line but not into the joint. In a desperate case open drainage may be necessary but this almost invariably leads to ankylosis especially when drains are inserted actually into the joint.

However where all the components of the joint are infected and the cartilage has already been destroyed the best that can be hoped for is ankylosis and therefore the treatment consists of fixation free drainage and the prevention of deformity. The joint is immobilized in the position which promises the maximum degree of function. In particular a careful watch is kept for dislocation which is often spontaneous in the hip and knee and which should be reduced as soon as the acute inflammatory symptoms have subsided.

ACUTE INFECTIVE ARTHRITIS OF INFANTS

Acute infective arthritis is not a disease of great frequency in children but carries with it the possibility of serious consequences to life and to future function of the limb. It appears usually in children under one year and is generally secondary to a neighbouring bone lesion, although less commonly the joint may be infected through the blood stream. Osteomyelitis has a predilection for the metaphysis and this in many cases is intra articular or virtually so since the articular capsule of the joint includes at least a portion of the metaphysis.

Infecting Organisms By far the greatest number of cases are caused by infection with the staphylococcus aureus or the hemolytic streptococcus. Less commonly the organism is the influenza bacillus, pneumococcus, colon bacillus or in fact any of the pyogenic organisms. Generally speaking infections produced by the staphylococcus are the most virulent and most destructive while those produced by the hemolytic streptococcus are only a little less severe. Seventy per cent of cases of acute coxitis in infants are due to streptococcal or pneumococcal infection. In later childhood and adolescence on the other hand the staphylococcal lesion predominates while practically all adult cases are due to streptococcal or pneumococcal infection. Cases of staphylococcal coxitis in adults are recurrences of an earlier infection.

The local source from which the general infection develops may be the oro nasal passages, skin or the umbilicus.

SURGICAL PATHOLOGY

The infection starts in the synovial membrane lining the joint. This rapidly becomes inflamed, swollen, and oedematous, and from its surface is poured out synovial fluid, plasma, and leucocytes filling the joint cavity with a turbid fluid containing large numbers of polymorphonuclear leucocytes and much fibrin. The synovial membrane has very similar powers to the peritoneum in combating infection and so long as it remains comparatively healthy and especially so long as the joint tension is not excessive it may deal successfully with a considerable degree of infection. If the infection is severe or prolonged the mesothelium lining the synovial membrane is destroyed and its place taken by a mass of granulation tissue. The articular cartilage is less readily involved than the synovial membrane which is fortunate since any injury to the cartilage results in greater or less impairment of the function of the joint. The cartilage is killed first and most extensively at points of contact between opposing articular surfaces. It is broken down partly by the absorptive action of the granulation tissue, partly by pressure erosion and partly by the digestive action of proteolytic ferments in the joint exudate.

SIGNS AND SYMPTOMS

The signs and symptoms of acute suppurative arthritis in a superficial joint are sufficiently clear to offer no appreciable obstacle to diagnosis. The onset is abrupt and in many cases is preceded by trauma. At an appreciable interval after the trauma usually twelve to twenty four hours the joint becomes painful swollen and hot. Movement and weight bearing are painful and quickly become impossible. Examination reveals muscle spasm fluid within the joint capsule and pain on the slightest movement. The joint is fixed usually in flexion. The temperature is elevated to between 100° and 103° and a polymorphonuclear leucocytosis is present. Blood culture often demonstrates a septicæmia. Finally the diagnosis is completed by aspiration of purulent fluid from the joint.

In infants the diagnosis may be rendered difficult by the feebleness of their general reaction to the infection since suppurative arthritis may exist without any elevation of temperature or leucocytosis. In such cases only the local signs of arthritis are present and aspiration of the joint is the only certain means of diagnosis.

It is to be noted that in early purulent arthritis when the articular cartilage is still unharmed there is a small range of movement which is entirely free from pain.

DIFFERENTIAL DIAGNOSIS

Suppurative joint infections are most frequently confused with *acute rheumatic fever*. In acute infective arthritis there is direct involvement of the joint surface and so the slightest attempt at active or passive movement of the affected joint is almost impossible and induces severe pain. In *acute rheumatism* there is often a preceding history of tonsillitis and the multiplicity of the joints involved together with the comparative mildness of the inflammation usually indicate the diagnosis.

In one type of mono articular infection there is occasionally some difficulty. In this group of cases there is a history of a rapidly developing pain in a joint along with the other signs of arthritis—increased local heat, redness, limitation of movement and effusion. Immediately thereafter multiple joint lesions occur in rapid succession but do not present the definite findings which the original focus demonstrated. They are probably toxic in origin but unless they subside in a short time leaving the original joint focus active the condition may be mistaken for acute rheumatism. These cases obviously do not respond to salicylates.

Tuberculous arthritis is often to be considered but in tuberculosis there is no leucocytosis and the progress is usually very indolent. There is also complete limitation of joint movement except in synovial tuberculosis. In children the tuberculin reaction is an aid to diagnosis.

and there are usually sufficient X ray evidences to differentiate the two conditions

Traumatic synovitis must also be seriously considered, for after some trauma there may be pain, limitation of movement, effusion, and occasionally elevation of temperature, and it may be difficult to say that the case is actually not one of infection. There is however, no increase in local temperature or leucocytosis, and no evidence of the systemic reaction. Pain and muscle spasm are relieved by immobilization, while in purulent arthritis these usually persist.

Hæmophilic arthritis though rare must be borne in mind. It may arise without known cause or significant trauma but there may be associated ecchymoses in the skin overlying the joint. The temperature may be slightly elevated. The history may be of assistance, because of hereditary transmission and more than one joint may be involved. If there is any suspicion of hæmophilic arthritis, it is advisable to investigate the coagulation time of the blood before resorting to any radical measures. It is usually unduly prolonged.

TREATMENT

Fraser says 'the ideal of successful treatment is to arrest the condition without having to resort to incision and drainage of the joint since risks of ankylosis are increased by such an operation.' Cotton wisely and tersely remarks that the treatment of a suppurative joint by incision and drainage is an outrage. Immediately the case comes under observation the joint is splinted in a position of slight flexion, and traction applied. Some warm soothing applications may be used but where an infant is concerned must be used with great care to avoid the risk of burning. Ten per cent ichthol in glycerine, or antiphlogistine are the best applications. Abundant fluids are given and the bowel evacuated by calomel followed by a saline purge. As soon as possible aspiration of the joint is carried out, and fluid withdrawn for examination. The joint should be emptied as far as possible. The type of fluid and the organism responsible for the condition, are now demonstrated and determine the future treatment of the case. If the organism is a streptococcus or a pneumococcus, then conservative treatment is persisted with, i.e. continued traction to the joint with repeated aspirations. In a successful case successive aspirations become *more serous* and after a time function is restored to the part by gentle movement and massage. If a staphylococcus is the cause and in many cases where it is a hæmolytic streptococcus, it is likely that operative measures will ultimately have to be resorted to and it is unwise to delay too long lest the patient become too debilitated to stand the operation.

When the organism has been recognized it may be that some of the sulphonamide group of drugs will be useful—Sulphomilamide against the streptococcus, or Sulphathiazole against the staphylococcus. These

are given in maximum doses and often may be so successful that aspiration will be the only other treatment needed. In cases which do not improve under aspiration the infection has either become too well established or masses of infected fibrin have formed inside the joint and cannot be evacuated except by arthrotomy. The joint is then opened and thoroughly cleansed the interior being irrigated with a mild antiseptic fluid such as acriflavine 1 in 3 000. The joint may



FIG. 183.—Old infective arthritis of the Hip Joint with pathological Dislocation and subsequent Ankylosis.

be flexed and extended at the same time to encourage complete emptying. In most cases the synovial membrane is stitched up and a drain of dentil rubber put down to the line of suture. Friction is continued and if the fluid reaccumulates it may be aspirated. If however, the aspirated fluid becomes increasingly purulent or the temperature rises and remains high and the general condition tends to deteriorate it may be better to institute continuous drainage of the joint until the general symptoms of infection have subsided. This in all probability means an ankylosis of the joint.

In cases with much general infection 1 in 500 acraflavine may be given intravenously. The maximum adult dose is 3 grains, i. e. 150 c. c. of 1 in 500 solution, and the amount used in a particular case is adjusted for the age of the child.

Aspiration of Joint Effusions

The importance of aspirating joint fluids both traumatic and inflammatory, is not sufficiently recognized. The accumulation of fluid expands the capsule, stretches the ligaments of the joint, interferes with the circulation and irritates the nerve endings, which in turn causes muscular spasm. Following trauma blood is absorbed slowly from the joint and produces inflammatory changes of the synovial membrane. Fibrin is precipitated and organized and may form a nucleus for the development of loose bodies. The cartilage undergoes degeneration. The immobilization of the joints may finally give rise to atrophy of muscles and bone.

In traumatic effusions aspiration is carried out twenty four hours after the injury. The severity and the type of the injury are then determined by examination of the fluid and by clinical methods. In cases of simple traumatic synovitis, non weight-bearing movement is allowed at once and weight bearing after a few days if the effusion does not recur.

Aspiration is indicated in inflammatory effusions if treatment for one week does not produce a marked decrease in the swelling. Reaspiration should be done at weekly or bi weekly intervals as long as necessary. As a precaution a different point of entrance should be used at each aspiration.

Even less recognized than the therapeutic value is the diagnostic importance of the aspiration of joint fluids. In slight injuries with a tear in the capsule only blood is found in the effusion. In cases of rupture of the semilunar cartilages of the knee and intra-articular fractures the effusion may contain fat which has been torn from the fat deposits in the joint or from the bone marrow.

The differentiation between inflammatory and traumatic effusions is another problem of importance from both a scientific and a practical point of view, especially in compensation and liability cases. The presence of blood in the aspirated effusion is of significance only in recent injuries. An icteric index higher than 6 is pathognomonic of traumatic effusion. The icteric index increases with the age of the effusion.

Examination of inflammatory effusions makes it possible to differentiate specific from non specific forms of synovitis and arthritis. Luetic arthritis can be diagnosed most accurately from the Wassermann reaction of the joint fluids. Reschke and others have reported positive Wassermann reactions in joint fluid in cases in which the Wassermann test of the blood was negative. In a study of 121 synovial fluids in cases of gonococcal arthritis, Kling and Pinkus found

the gonococcal complement fixation test to be specific and to give stronger and more positive reactions than the blood serum. In tuberculous arthritis the effusion sometimes contains so many organisms that they can be demonstrated in the sediment but for diagnostic purposes it is usually necessary to resort to animal inoculation of the fluid.

The etiology of chronic non specific arthritis is far from definitely determined. In the laboratory of the Hospital for Joint Diseases New York about 20 per cent of the fluids examined developed colonies of streptococci, staphylococci or diphtheroid bacilli. The study of the cells in the synovial fluid gives some indication of the underlying process. Forkner came to the conclusion that a count of over 11 000 leucocytes with 60 per cent polymorphs in chronic non specific arthritis is likely to be associated with a positive bacterial infection and that a cell count under 5 000 leucocytes with fewer than 50 per cent polymorphs is likely to be associated with negative bacteriological findings.

Methods of Aspiration and Drainage

Before undertaking the treatment of acute arthritis in any joint it is essential to know the method and the site of aspiration, the mode of approach for drainage and the optimum position should ankylosis supervene.

The Hip Joint

Aspiration The hip joint may be aspirated either through a lateral or an anterior route.

(a) The needle is entered at a point 2 inches below the anterior inferior iliac spine and pushed upwards, backwards and medially.

(b) The needle is inserted from the side just above the upper border of the great trochanter and thrust inwards and slightly upwards in a line almost parallel with the femoral neck.

Method of Drainage The hip joint should be drained from its posterior aspect. The incision runs parallel to the central axis of the neck of the femur and extends to the tip of the trochanter. The gluteal fascia is exposed and divided in the line of the skin incision. The fibres of the underlying gluteus maximus are thus laid bare. These are separated, and the sciatic nerve in the median angle of the wound carefully preserved. The gemellus superior is detached from the tendon of the obturator internus to enable the capsule to be split longitudinally throughout its entire length. The head, neck and acetabulum are now exposed, and the appropriate treatment carried out.

This method provides rapid dependent drainage and does the minimum of injury to anatomical structures. There is practically no bleeding.

The Optimum Functional Position Should unilateral ankylosis of the hip be anticipated the joint is placed in a position of extension, very slight abduction and very slight lateral rotation. When both hips

are affected one joint should be immobilized with some degree of flexion, so that the patient can sit with some comfort

The Knee Joint

Aspiration A needle can be introduced into the knee joint at any point along the medial or the lateral border of the patella. The patella should first be grasped, pulled to the opposite side, and the needle

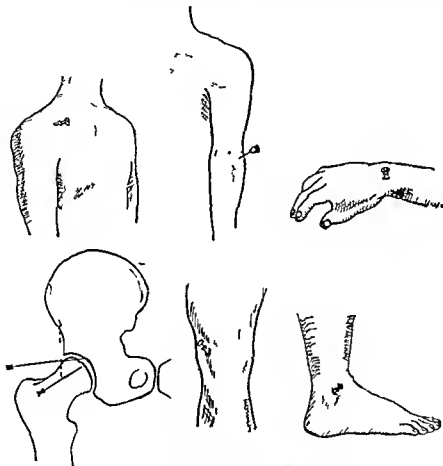


FIG. 190—The Routes of Aspiration of Joints.

passed obliquely between the femur and the patella while the quadriceps muscle is relaxed

Method of Drainage The anterior compartments of the knee may be opened on either or both sides of the patella, a short transverse incision being made through the capsule. Except in the grossly infected joints of modern warfare the capsular opening should invariably be closed after the joint has been evacuated and irrigated. Strips of rubber dam may be inserted down to the capsule in order to drum off the leakage of the first few days.

The Optimum Functional Position The knee joint should be fixed

either in extension, or, in young people whose epiphyses are still active, in a few degrees of flexion

The Ankle Joint.

Aspiration The ankle joint is entered from the front between the lateral border of the peroneus tertius and the lateral malleolus, or between the medial border of the tibia anterior and the medial malleolus. The needle is thrust backwards and slightly downwards, and should gain the interval between the tibia and the talus, which has been previously recognized by palpation. The joint may also be aspirated from the back, between the tendo calcaneus and the peroneal muscles.

Method of Drainage The ankle joint cannot be adequately explored unless one or other of the lateral ligaments is partially or completely divided. The best approach is the lateral J incision of Kocher which runs down the back of the fibula and turns forwards below the lateral malleolus. The anterior talo-fibular ligament is divided and the joint exposed and irrigated.

The Optimum Functional Position When the ankle is to be immobilized the foot should be placed at right angles to the leg and very slightly inverted.

The Shoulder Joint

Aspiration Aspiration of the shoulder joint is carried out by inserting the needle at some point in the delto-pectoral triangle, and thrusting it through the anterior part of the capsule. The joint may also be punctured between the acromion process and the head of the humerus, the needle being inserted below the anterior border of the acromion, and pushed downwards and backwards. On the lateral aspect, the subacromial bursa, when distended, offers a convenient route of aspiration, the needle being inserted just below the lateral edge of the acromion, either at its mid point or towards the posterior end.

Method of Drainage The shoulder joint is exposed best through an anterior incision, which usually runs parallel to the fibres of the deltoid from a point 1 inch lateral to the coracoid process. When the deltoid fibres are separated the capsule is brought into view.

The Optimum Functional Position The arm is abducted if ankylosis is anticipated, in this way the function of the limb is least interfered with. The angle of abduction should be 75 degrees, the elbow joint being in line with the front of the chest and the humerus laterally rotated 15 degrees.

The Elbow Joint

Aspiration The elbow joint may be approached from the back. The needle is introduced immediately above the olecranon, and equidistant from the epicondyles, with the elbow flexed to about 135 degrees.

An alternative and better route is to insert the needle at the lateral side of the olecranon, with the elbow at a right angle. This lateral

approach is easier since the head of the radius can be readily rotated and in this way the position of the joint defined

Method of Drainage For most purposes the elbow joint can be quite adequately explored by incising the radio humeral capsule counter openings being made when necessary on the medial side of the olecranon When it is essential to expose the entire joint a posterior approach must be used The triceps tendon is divided $\frac{1}{2}$ inch above its insertion into the olecranon and reflected upwards

The Optimum Functional Position Where ankylosis of the elbow is inevitable and only one side is affected the joint should be immobilized at an angle of 110 degrees Since fixation of the elbow also abolishes the forearm movements the occupation of the patient must be carefully considered when this question arises and this is particularly essential in dealing with the right elbow in right handed persons Workmen who require to use a shovel prefer a position of full supination whereas those who use their arms principally for writing—clerks for example—are satisfied with the forearm fully pronated

The Wrist Joint

Aspiration The needle is introduced posteriorly immediately below the lower end of the radius between the extensor indicis proprius and the extensor pollicis longus It passes directly into the radio carpal joint

Method of Drainage The wrist may be opened from the dorsum between the tendons of the extensor indicis proprius and the extensor pollicis longus or between the extensor carpi ulnaris and the extensor digitorum communis

The Optimum Functional Position Where ankylosis of the wrist is anticipated it should be immobilized in dorsiflexion since in this position the strength of the grip is infinitely greater than it is when the wrist is flexed In addition a flexed wrist is used almost solely for picking up small objects

Ankylosis of the wrist joint is accompanied by loss or limitation of the movements of pronation and supination These can be restored by a simple operation One inch of the lower end of the shaft of the ulna is excised and the raw end covered with fascia lata The lower end of the radius now moves with the wrist and pronation and supination are possible

PNEUMOCOCCAL ARTHRITIS

Pneumococcal infection of a joint though rare and of grave prognosis is occasionally encountered As a rule a single one of the larger joints is involved but in 25 per cent of cases the disease is polyarticular It appears that previous disease of the joint such as gout or rheumatism predisposes to the pneumococcal infection

The condition usually arises in association with some other pneumococcal lesion such as pneumonia or otitis media and it may begin

during the actual septicaemic stage or during convalescence. A common time of onset is about two weeks after the commencement of pneumonia. In certain cases the joint manifestation has actually preceded a pneumococcal pulmonary infection indicating the septicaemic nature of the process. Pneumococci may or may not be obtained by blood culture. Infants and alcoholics are most liable to the infection.

A primary form is said to occur in children but this should be accepted with caution since it is probable that in the majority of those so called idiopathic cases a previous focus of infection has been overlooked.

The synovial membrane alone may be involved or the articular cartilage and even the bones may be attacked and the joint become completely disorganized. In the so called 'primary' cases the onset is sudden the joint becoming distended with fluid which is at first serous and very soon purulent. The pus is greenish yellow and contains flakes of fibrin. Pneumococci can usually be demonstrated and their presence constitutes the main point of distinction between this and other forms of acute arthritis.

In the secondary cases e.g. those secondary to pneumonia the clinical features do not appreciably differ. The diagnosis however is easier owing to the obvious primary focus. The diagnosis is suggested by the occurrence of signs and symptoms of joint infection in the course of the pneumococcal illness and is confirmed by examination of the fluid aspirated from the joint.

PROGNOSIS

The disease is very fatal. In Herrick's series of cases the mortality was over 65 per cent. Even if the patient recovers the convalescence is prolonged and a considerable degree of ankylosis is usually inevitable.

TREATMENT

A serous effusion may be treated, as usual by aspiration. If the effusion is frankly purulent the joint should be exposed and drained in the same way as in ordinary septic arthritis. Anti pneumococcal serum especially Felton's has been used intravenously with benefit but the sulphonamides are now preferred. In children sulphathiazole and in adults sulphadiazine are the drugs preferred and are given in full doses.

GNOCOCCAL ARTHRITIS

In from 2 to 5 per cent of all cases of gonococcal urethritis, an infective joint lesion arises known as gonococcal arthritis or gonococcal, or gonorrhoeal, rheumatism. It develops usually during the third week of the infection although occasionally it arises only when the disease

is on the decline, even some months after the original urethritis. It is stated to be four or five times more common in men than in women, and the usual age period is from 20 to 30 years, largely because gonorrhœa is more frequent then. The joint manifestations persistently tend to relapse and recur.

ETIOLOGY

Among the predisposing causes the most important is lack of treatment in the earlier stages of gonorrhœa, while active or heavy exercise during the acute stage also tends to produce an arthritis. Recurrence of infective manifestations in a joint frequently follows reinfection or the lighting up of a chronic focus.

The infection of the joint is metastatic, and the organism is carried by the blood stream to the affected joint. It is interesting to note in this connection that in cases of acute arthritis it is often difficult to find the organisms in joint fluid after a few days. They seem to disappear from any encapsulated fluid collection after a time.

The disease is monoarticular in 40 per cent of cases but frequently a number of joints become infected during some stage of the illness, with recovery in all save one. This residual monoarticular affection is resistant to treatment, and it may be lighted up by the passage of a bougie. The large joints are involved with greater frequency than the small ones, the knee being most frequently affected. The order of frequency in Lees' series was as follows: knee, ankle, metatarso phalangeal, shoulder, wrist, metacarpo phalangeal and elbow joints. The joints of the right side of the body appear to be more frequently involved than those of the left, and the wrist joint is more frequently attacked in women than in men.

PATHOLOGY

Acute cases may be divided into four types:

- (1) Arthralgia in which one or more joints may be painful but there are no gross physical signs.
- (2) An acute infection with effusion in one or more of the larger joints.
- (3) An acute infection with erosion of cartilage in addition to the effusion.
- (4) An acute infection involving the synovial membrane and the articular surfaces. The intra articular exudate becomes purulent and there is marked ulceration and erosion of all the cartilaginous surfaces. This condition is comparatively rare.

Subacute and chronic cases may be divided into two main types:

- (1) A synovial type, involving especially the knee joint. The synovial membrane is thickened, and there is a moderate effusion.

(2) A mixed type involving both the synovial membrane and the articular surfaces and frequently polyarticular in the smaller joints in which the serofibrinous exudate is always fibroblastic and leads to adhesions and deformity. Proliferative changes are more evident than destructive ones and the peri articular tissues are involved in the fibrosis in almost every case.

SYMPTOMS

The acute joint infections other than arthralgia begin suddenly and are often ushered in by a chill or a rigor. The temperature is raised and the joint is painful. The pain rapidly becomes excruciating and is attended by muscular rigidity. The skin overlying the joint becomes red and hot and peri articular œdema soon manifests itself. When the joint effusion becomes purulent pyrexia is increased and rigors occur.

The acute form may subside into a chronic type or a sub acute or chronic infection may arise *de novo*. The symptoms resemble those of the acute phase but are milder except during the acute exacerbations which are liable to occur. The associated muscles become atrophied and there is a persistent joint effusion. When there is gross enlargement of one joint—e.g. the knee—in the absence of febrile and other symptoms the condition is known as hydrops dropay or hydro arthrosis. Suppuration is rare in this form.

The tendons the tendon sheaths the bursæ and the periosteum may be inflamed in association with gonococcal arthritis. This is especially so of the tendons of the wrist and ankle and of the retro calcanean bursa. In severe cases the adjacent bones are rarefied.

DIAGNOSIS

A painful affection of a joint whether acute sub acute or chronic and which is associated with peri articular changes should prompt tactful inquiries concerning urethral discharge. The latter may be extremely slight—e.g. a morning drop—or there may be no discharge but a palpable enlargement of the prostate or of the seminal vesicles. The secretion of these organs may be expressed by finger massage and may show gonococci on examination. Even when a urethral discharge is present it may be difficult or impossible to isolate the gonococcus but the presence in the film of an excessive number of polymorphs should be sufficient to suggest the diagnosis when the discharge is of long standing.

Even when there is no obvious focus of gonococcal infection it is always important to exclude this type of joint lesion by repeated examinations when an acute subacute or chronic affection of a joint is painful persistent and associated with peri articular changes.

It is important in acute cases to be able to differentiate between

acute rheumatism and a gonococcal arthritis. The following are the main distinctions as laid down by David Lees.

| ACUTE RHEUMATISM | GNOROCOCAL ARTHRITIS |
|---|--|
| 1 No evidence of genito urinary disease | Often definite genito urinary symptoms and signs |
| 2 Marked temperature reaction and more prolonged constitutional upset and prostration | Very moderate temperature reaction, and constitutional upset slight, except in purulent cases |
| 3 Sweating very profuse, with acid odour | Very little sweating except in purulent cases |
| 4 Pain intense and aggravated by the slightest touch | Pain less intense |
| 5 Many joints involved, but as pain leaves one it flits to another, and the first affected appears to be free from discomfort | May be limited to one joint, and usually one or two joints only, and pain does not leave a joint rapidly and pass to another |
| 6 Tendon sheaths and peri articular tissues rarely involved | Tendon sheaths and peri articular tissues very frequently the site of disease. |
| 7 More common in women | Less common in women |
| 8 Often some cardiac complication, such as endocarditis or pericarditis, and an active focus of infection in the tonsil | Cardiac complications very rare, and no acute condition in the tonsil |
| 9 Symptoms and temperature react extremely well to the administration of salicylates | Salicylates have little effect on the pain, the swelling, or the temperature |
| 10 Complement fixation test of blood negative | Complement fixation test usually positive |
| 11 Temporo mandibular joint rarely involved | Temporo mandibular joint may be involved |

Acute gonococcal arthritis must, in addition, be differentiated from arthritis following on pneumonia, dysentery, cerebro spinal, typhoid, or scarlet fevers, acute tonsillitis, and tuberculosis.

An acute *tuberculous arthritis* is more insidious in onset, it is rarely polyarticular, the pain is not so severe at first, there is often epiphyseal involvement, and X ray examination will reveal a definite lesion of the bone.

In *pneumococcal arthritis* the joint fluid almost always contains pneumococci. In other cases of *pyogenic arthritis* the typical signs of the primary disease, such as scarlet or typhoid fever, etc., are of the greatest help in accurate diagnosis.

In acute joint involvement X rays are of little assistance except in differentiating it from acute tuberculous disease. In tuberculosis there is often definite evidence of osseous change, especially in the region of the metaphysis, and the changes are destructive and not proliferative and reparative as in gonorrhoea. When the activity of a tuberculous joint has ceased the definition becomes more distinct, but the articular surfaces have a worm eaten appearance.

In acute gonococcal arthritis the complement-fixation test gives a positive reaction in a large number of the cases (75 per cent), if it is

carried out later than ten days after the infection. In subacute and chronic cases in which the arthritis is generally later in appearing the number of positive results is larger still and is close on 80 per cent. A negative complement fixation test does not exclude gonorrhœa as the cause of the joint infection and a positive test is strong confirmatory evidence of its etiology.

PROGNOSIS

The prognosis in the first three groups of gonococcal arthritis—arthralgia, acute and subacute synovitis and acute and subacute synovitis and arthritis—is invariably good even when there is involvement of the periarticular structures if treatment of the original focus of infection and of the joint is carried out on correct lines. In the fourth group—acute arthritis with suppuration—surgical interference is often required and there may be considerable loss of function. Subacute and chronic cases react well to treatment but recovery is always slow and the joint condition is apt to recur.

TREATMENT

Lees describes the treatment of this condition under four heads.

(1) **General Treatment** In this the main essentials are rest, mild purgation, diuresis, diaphoresis by tepid sponging and restriction of diet.

(2) **Eradication of the Original Focus of Infection** This need not be discussed here but it is wise to emphasize how important it is to treat all male cases in the early stages when the anterior urethra alone is involved. In the more chronic cases the importance of prostatic and vesicular massage may be emphasized.

(3) **Treatment of the Infected Joints** Relief of pain is of primary importance and is obtained by rest in a semiflexed position. While rest is advisable if the pain is severe it is very important not to continue immobilizing the joint for any period longer than is necessary to relieve the acute pain. Early mobilization is one of the greatest assets to the recovery of joint function. Next in importance to the relief of pain is Bier's hyperæmia and third the local application to the joint of soothing medicaments such as antiphlogistine or tincture of lead and opium. Diathermy to the joint and to the focus of infection appears to be a definite advance in the treatment of this condition.

Operative treatment has been advocated largely on the Continent, but it is doubtful if more than a few acute or subacute cases require operative interference. Aspiration will undoubtedly relieve the intra-articular pressure. If incision and lavage is required 2 per cent. formaldehyde and glycerine or 1 in 5 000 acriflavine is used. Operative treatment is usually reserved for purulent cases in which there is evidence of rapid cartilaginous destruction. In chronic cases operative measures are required to correct deformity.

(4) Treatment through the Blood-stream

(a) *Protein Therapy* In the acute stages aolan or sterile milk is preferred, as the reactions which they give are not excessive and yet their therapeutic effect is often quite marked. In chronic cases peptone is probably the best protein to use.

(b) *Vaccine Therapy* In general this method of treatment is preferable to protein therapy, but the vaccines may be supplemented by one or two initial injections of a protein such as milk. A detoxicated vaccine and an autogenous one made from the patient's own infecting organism are used in combination.

(c) *Chemotherapy* The sulphonamide group is of considerable value in the acute stages and although claims have been made for many members of the group sulphapyridine and sulphathiazole seem to be more effective and less toxic.

SYPHILIS OF JOINTS

True syphilitic arthritis is due to the virus of syphilis and is not merely an arthritis occurring in a syphilitic subject. The lesion is curable by anti syphilitic treatment if diagnosed early and this provides an important criterion in diagnosis, one even more important than the Wassermann test.

The condition appears to be more common than is supposed, but as it is now believed that a case of syphilis treated efficiently will never develop arthritis it seems likely that with present-day organizations for treatment the affection will become increasingly infrequent.

Syphilis of the joints may occur at all stages of the disease, and in both the congenital and acquired forms. Many different types and transition forms occur so that it may well be said to be a protean condition.

Classification of Syphilitic Arthritis

Todd described this affection of joints in his Hunterian Lecture and it is from that admirable monograph that this description is taken. He uses a classification which, in an abbreviated form is given here.

Joint Lesions in Congenital Syphilis

Synovitis

Syphilitic osteochondritis

Joint Lesions in Secondary Syphilis

Arthralgia

Hydrarthrosis

Joint Lesions in Tertiary Syphilis

Gummatous arthritis

(1) The synovial form

(2) The osseous form

Arthritis in Congenital Syphilis

In addition to the two forms that are described below as occurring in congenital syphilis, we meet with others which are exactly analogous to the tertiary syphilitic form met with in adults.

1 Parrot's Syphilitic Osteochondritis. This is an epiphysitis, or a *juata* epiphyseal inflammation, which occurs during the first few months of life in about 5 per cent of children with congenital syphilis. It affects the upper limbs more frequently than the lower, and consists of a gelatinous change in the cartilage and bone, often associated with an effusion into the adjacent joint. The gelatinous tissue breaks down to form a greenish yellow fluid from which a strongly positive Wassermann reaction is obtainable. Suppuration may or may not occur. The extremities of the bones at which growth principally takes place—knee, shoulder and wrist—are more frequently involved, the epiphyseal region becoming large and tender. Separation of the epiphysis may occur and give rise to unwillingness to move the joint—syphilitic pseudo paralysis.

The *X ray* changes are irregularity of the epiphyseal line, cupping of the metaphysis, widening of the articular space, thickening of the periosteum, and decalcification of the neighbouring bone.

Anti syphilitic treatment may produce complete resolution but the growth cartilage may be so damaged that, later, shortening or deformity arise.

2 Clutton's Joints (Symmetrical Hydrarthrosis) The joint condition commonly known by this name was first described by Clutton in 1886, and consists of symmetrical hydrarthrosis of the knee in children from eight to sixteen years of age. The onset is insidious and there is no fever. The joints are painless, and in spite of the effusion the patients are able to walk quite well. This condition when associated, as it commonly is, with eye changes and other stigmata of congenital syphilis, constitutes a striking clinical picture. Syphilis is practically the only cause of a bilateral, painless hydrops of the knee in a child.

The condition responds well to treatment, though it is somewhat prone to relapse unless the treatment is prolonged.

Syphilitic Arthritis in Adults

Arthritis is more severe in the later stages of syphilis. It affects the joint structures more deeply and is much more destructive, and also more resistant to treatment. Unless diagnosed early and treated vigorously it becomes one of the most disabling of joint affections.

1. Arthralgia. The commonest joint manifestation in acquired syphilis is a simple arthralgia, which forms part of the clinical picture in the secondary stage. It may even appear before the early rashes. The pain is never severe and can often be more correctly described as an ache. As in tertiary syphilis, it is chiefly nocturnal. It is characteristic of it that movement does not increase the discomfort, an important point in the differential diagnosis from rheumatism. It usually affects one or more of the larger joints, there is little, if any,

muscular spasm and usually at this stage there is no local swelling heat or tendency to deformity

The diagnosis is determined by the history and general phenomena and the positive Wassermann reaction

2 Hydrarthrosis Later in the secondary stage serous synovitis may occur and may be acute sub acute or chronic It usually involves two or more joints especially the knees and often in a symmetrical manner In the earlier cases the synovitis is of a transient nature but later it is more persistent Fluid is abundant and the synovial membrane is swollen Pain is moderate and gentle passive movement does not hurt although direct pressure on the joint may do so The condition is usually of a mild type but in exceptional instances it may be acute and even simulate suppuration when pain tenderness malaise and pyrexia are present

A rarer and later type in the secondary stage is a plastic arthritis The synovial membrane is thickened and the joint swollen though very little fluid is present The fluid turbid and thick invariably gives a positive Wassermann reaction The affection is usually mono articular but may be polyarticular in neglected cases Larger joints such as the knee are usually affected The response to treatment is slow but most cases eventually recover The later the institution of treatment the more chronic the disease will be

Tertiary Syphilitic Arthritis

(Gummatous Arthritis)

Gummatous arthritis may affect a whole joint or be localized to a part of a joint Its onset is usually insidious less commonly acute and sudden usually the joint has been previously normal though occasionally it is superimposed on a secondary syphilitic joint lesion such as hydrarthrosis The form of the disease occurring in congenital syphilitic children is known as van Gies joint Axhausen has described two forms of the disease

1 The Synovial Form This type occurs in children and often follows trauma which may lead to an erroneous diagnosis of tuberculosis The commonest joints to be affected are the knee ankle elbow and shoulder but smaller ones such as the inter phalangeal joints are occasionally affected There is considerable but as a general rule painless effusion but exceptionally pain may be severe and the disease simulate tuberculosis The pathological changes are limited to the outer layers of the capsule and consist of thickening and perivascular infiltration The lining endothelium and articular cartilage remain shiny

The disease can be distinguished from tuberculosis by the fact that there is less muscular wasting and that even after years of neglect there may be little pain and little restriction of movement whilst suppuration is practically unknown and no other complications occur

It is therefore wise to exclude syphilis in any doubtful chronic joint infection

2. The Osseous Form. When this occurs in young patients, it may be primarily an epiphysitis, with secondary involvement of the articular surface, which becomes eroded and irregular. Cavitation may be present in the interior of the epiphysis, together with bony outgrowths at the articular margins. In adults, the whole of one large joint is affected—as a rule the knee. The condition resembles osteo arthritis, both pathologically and on X ray examination. Distension of the joint is present, and some increase in the density of the peri articular soft parts can be detected in the radiogram.

The spine is sometimes affected and the disease then closely simulates tuberculosis, the correct diagnosis being made only when some obviously syphilitic lesion, such as interstitial keratitis, makes its appearance.

Even in well established gummatous arthritis, timely treatment can produce great improvement, though not so much as in the earlier cases. It is important to institute thorough and prolonged treatment, since if it is delayed gross osteo arthritic like changes occur, or else ankylosis. The development of fibrous ankylosis is particularly deplorable, because there is a greater risk of non union in attempting to convert this into a firm bony ankylosis by arthrodesis than there is in a tuberculous case. This risk remains even after a thorough prophylactic course of anti syphilitic treatment.

A weight-bearing caliper should be worn throughout the active stage of the disease, but it should be taken off daily so that the joint may be put through its full range of movements without weight-bearing.

A form of syphilitic arthritis may occur both in children and adults which resembles acute rheumatism. Several joints may be involved simultaneously, but as a rule one more severely than the others. The joints affected, in order of frequency, are—knees, ankles, wrists and elbows. Frequently as one joint is getting better another becomes involved, and this may lead to a suspicion of rheumatism, but the condition does not respond at all to salicylates, and the progress of the case is much slower than in acute or sub acute rheumatism. Keratitis occurs in about 75 per cent of the cases. There is little pain, little or no muscular wasting, and the temperature seldom reaches 99°. The clinical picture of a painless polyarthritis in a child, without local heat, redness, wasting, pyrexia, night-starting, or response to salicylate treatment makes up a characteristic picture.

In young adults a similar condition occurs, but it is much more acute. The pain is often considerable, the joints are tender, swollen and red, and the temperature may be raised, even to 103° or 104°. Copious night sweating is frequent. The condition, however, does not respond to salicylates, so that Todd says that so-called "acute rheumatism" which does not react to salicylates is almost certainly syphilitic.

There is another form which simulates rheumatoid arthritis, with fusiform swellings of the fingers, sweating, pain, debility, intermittent pyrexia, with exacerbations and remissions

GENERAL DIAGNOSIS

The family history and that of previous diseases and of the present condition should all be fully considered. The Wassermann reaction should be tested as a routine in every case of chronic arthritis of any degree of severity. Both the blood serum and, if obtainable, the joint-fluid, should be investigated, for in a number of cases a positive result will be obtained from the fluid when the blood serum gives a negative result. Todd says a negative Wassermann reaction cannot be assumed to exclude the possibility of syphilitic arthritis, in cases of late congenital syphilis, at any rate until the effect of a course of anti-syphilitic treatment has been tried. As a corollary to this it might be added that in all cases of chronic arthritis in which, despite investigation, the diagnosis is not clear, anti-syphilitic remedies should be tried.

There are certain clinical features which Todd has pointed out as of diagnostic importance and which should make one think of syphilis

Painlessness, in spite of profuse hydrops, especially when associated with a free range of movement

Symmetrical synovitis

General health unimpaired in many cases in spite of prolonged joint affection

Failure to respond to certain specific drugs, e.g. salicylates.

Persistence of the condition in spite of treatment that would be successful in other conditions—rheumatism, tuberculosis, etc

Nocturnal occurrence of pain

Associated evidence of syphilis

Failure to produce tuberculosis, after injection into a guinea pig of some of the aspirated joint-fluid, may be of assistance in the differential diagnosis

HÆMOPHILIC ARTHRITIS

John Otto wrote the first important description of this disease, hæmophilia, in 1803, and in it he postulated Nasse's law that the disease is transmitted by females and manifests itself only in males. Hæmophilic arthritis, also known as "bleeder's joint," was first described by Volkman in 1868. König in 1892 divided the condition into three stages: (1) hæmarthrosis, (2) pan arthritis, and (3) the regressive stage. He warned against operation under a mistaken diagnosis.

PATHOLOGY

It is doubtful where the defect in the clotting time lies in this disease, but it is likely that there is some qualitative alteration which results in delayed activation of thrombin by prothrombin.

The hæmorrhage usually results from injury, and the joint quickly becomes distended with blood which is under considerable pressure and does not clot. It gives rise to mechanical disability, and, acting as an irritant, induces hyperplasia of the synovial membrane. Phagocytic macrophages accumulate in the subsynovial tissues, where they die, releasing the blood pigments from phagocytized red blood cells. With each new hæmorrhage this process is repeated, and the periarthicular tissues become saturated with blood pigment. In this way a dense layer of fibrous connective tissue is formed, and the size of the joint and the movement at it are steadily diminished in consequence, so that a fibrous ankylosis may result. If the bleeding ceases the synovial membrane may return to normal, but if it does not then the cartilage eventually becomes eroded around its margins through the encroachment of the hyperplastic synovial membrane. There may in addition be some patchy destruction of the cartilage over the articular surface. Such areas are irregular and map-like in contour, and not situated at the points of greatest pressure in the joint.

In the bone, the characteristic change consists of cavitation in the intra-articular portion, either at the articular surface or deep in the cancellous bone. Key believes this is due to intra-ossæous hæmorrhage in the atrophic bone, followed by aseptic necrosis and absorption. These areas of bone destruction can frequently be visualized by X-ray and when present are characteristic of advanced hæmophilic arthritis. When the patient grows older and bleeding ceases the condition of the joint may simulate that in hypertrophic arthritis. Marked deformity occurs as the disease progresses and the X-ray and clinical findings may simulate those of any type of arthritis.

THE CLINICAL PICTURE

This varies with the stage of the disease. Key recognizes two stages.

(1) **Acute Hæmarthrosis.** The joint disturbances of hæmophilia nearly always begin in childhood and the child may be seen by the surgeon during the first attack or only after repeated attacks in that or other joints. The hæmarthrosis usually follows a minor injury or strain, and the blood may gather slowly or rapidly, it may be slight in amount, or copious and under considerable pressure. Pain and loss of function may be slight or severe, varying directly with the amount of effusion. There is accompanying muscle spasm. At the superficial joints the skin may be cyanosed, but there is no increase in local heat or redness. The general temperature is slightly elevated, and there is usually a moderate leucocytosis.

(2) **The Chronic Arthritic Stage** In this stage permanent changes are present in the joint. They may follow the first attack but are more often the sequel to several attacks. The joint remains swollen, tender, sore and painful for several weeks or months. The arthritis progresses. Repeated attacks of acute pain and swelling occur, with permanent and increasing disability of the joint in the shape of contracture, deformity, and peri articular thickening. Muscle atrophy also increases after each fresh hæmorrhage. The coagulation time of the blood tends to be prolonged to a varying degree.

TREATMENT

In the first stage, the patient is put to bed and the joint immobilized by splints or plaster of Paris. Aspiration may be definitely dangerous. When the swelling and the pain subside, function is gradually restored with gentle massage and exercises. Every effort is made to avoid trauma in the future.

In the stage of chronic arthritis any deformities that have been produced may be corrected, if they are definitely incapacitating by some non operative, conservative means. Simple traction or wedging plaster cases followed by splints to maintain the corrected position, may be used but every effort should be made to traumatize the joint as little as possible. Where there is no incapacitating deformity the joint may simply be supported, in the case of the leg joints this may be done with a Thomas's walking splint, though sometimes a simple elastic bandage affords sufficient comfort. The usual methods are used to combat the hæmophilia and to reduce the coagulation time, and blood loss is remedied by blood transfusion. Platelet extracts, horse serum, snake venom, albumin or extract of white of egg tissue fibrinogen and ovarian extract (theelin) have all been used and the mere number indicates their comparative futility.

HYSTERICAL JOINTS

A hysterical or neuromimetic or functional joint is one in which the subjective symptoms complained of are without organic basis or where the complaint is out of all proportion to the organic signs. When a definite pathological change exists, the symptoms are both greatly exaggerated and persist for an unduly long period, owing to a superimposed hysteria.

Functional joint affections occur most frequently in young women, and generally in persons of an emotional type. Children are not often affected, but in later childhood typical cases are sometimes seen. Trauma is the most frequent antecedent condition, and the affection is seen in its typical form in medico legal cases where compensation is being claimed, although in such cases frank malingering has also to be considered. The onset may also be attributed to exposure to

cold, or be associated with some emotional or sexual disturbance. Occasionally it appears to be a subconscious imitation of an organic joint disease from which some friend suffers.

CLINICAL FEATURES

The symptoms develop suddenly, without reasonable cause, are exaggerated and sometimes bizarre, for example, the knee may be rigidly extended or flexed to its fullest capacity. In the lower extremity limp may be excessive, or a gait may be adopted which at once arouses suspicion.

The joints most commonly affected are the hip, knee, spine and ankle. It is notable that with the exception of the larynx parts supplied by cranial nerves are rarely affected. A hysterical paraplegia is rarely absolute or limited to a particular group of muscles, but takes the form of general inability of the limbs to perform a complex co-ordinated movement such as walking. Thus a patient, while able to move the legs with normal power and co-ordination while in bed, is unable to stand, or she can hop or jump although unable to walk.

When the affection follows a slight injury the patient complains of severe pain, excessive tenderness and impaired function of the joint. On examination the joint appears normal, but the skin over it is exquisitely sensitive. Stiffness is common and in some cases amounts to absolute rigidity. The joint may be fixed either in flexion or extension, but it is rarely in the exact position of ease assumed in a true joint inflammation and the position is apt to be changed from day to day and from hour to hour. When the patient's attention is diverted, the pain and stiffness may disappear.

Should the symptoms be unduly prolonged disuse atrophy of the tissues may ensue, while circulatory changes from the same cause, such as undue pallor, temperature changes and undue perspiration, are not unusual. Secondary contractures of the joint set in if the joint is kept rigid for long periods.

Hysterical phenomena at joints are seldom found alone, but are associated with other, possibly latent stigmata, such as globus hystericus, zones of anæsthesia, and convulsions.

DIAGNOSIS

In every case of alleged hysteria a careful examination must be carried out to eliminate the possibility of a true organic lesion. The ordinary clinical examination may be supplemented if necessary by one under anæsthesia, and by X-rays.

In examining the case, the observer will usually note that the signs disappear when the attention is diverted, that they are out of all proportion to the local evidences of disease, that there is no sign of joint destruction, and that a light touch may cause more pain than does firm pressure.

DIFFERENTIAL DIAGNOSIS

Hysterical affections of joints have to be differentiated from those joint disorders which are reflex in nature. The hip joint is a common site for such disturbances, and the commonest cause appears to be preputial adhesions, although anal, vaginal and coccygeal lesions are also common aetiological factors.

The distal part of the extremity must be inspected for evidences of a septic lesion, as joint stiffness or fixation is frequently associated with infection in the inguinal or popliteal glands secondary to an area of peripheral sepsis.

TREATMENT

An accurate diagnosis is essential to successful treatment. The general health should be carefully tended, and a nourishing and easily digested diet instituted. Constipation should be corrected and tonics administered if necessary. The local condition should be explained to the patient as due to an abnormal state of the circulation and innervation of the joint. It is wise to refrain from saying that nothing is the matter or that it requires only an effort of will to overcome it, for this view will not be accepted and her co-operation and confidence are essential. If possible the patient should be sent away from the harmful sympathies of her home and in severe cases should have the rest treatment described by Wear Mitchell.

Deformity should be corrected—if necessary under an anæsthetic. The gradual use of the limb should then be begun and progressively increased without regard for the pain caused by it. In serious cases, it may be advisable to assist the limb with crutches or a walking caliper in order to get the patient on to it. Along with this progressive increase in use should go measures to stimulate the local circulation and to improve the muscles, in the form of massage, exercises, hot-air baths and electrical stimulation. Morphia or splints should never be used.

HYPERTROPHIC PULMONARY ARTHROPATHY

A syndrome affecting the osseous and other tissues of the extremities may arise in association mainly with chronic intrathoracic disease. The most characteristic features of the syndrome are (1) clubbing of the fingers, (2) changes in the bones, and (3) changes in the joints. When all these are present they are spoken of as Marie's sign group, after the observer who first drew attention to the disease in 1890.

The condition is found in a variety of conditions

- 1 *Pulmonary suppuration*—bronchiectasis, empyema, pulmonary tuberculosis, abscess—especially the first mentioned.
- 2 In some cases of *chronic valvular disease of the heart*, especially when there is chronic venous congestion.
- 3 In *sypilis of the lung*.

4 In *malignant disease of the lung*

5 In some cases of *aneurysm of the thoracic aorta* or its branches
When one of the branches is affected the condition may be unilateral

6 In some cases of *gastro intestinal or hepatic disease*—e.g. chronic diarrhoea and hypertrophic biliary stenosis

7 Occasionally in *spinal caries* and *psoas abscess*

THE CLINICAL FEATURES

(1) *The Clubbing of the Fingers* The terminal phalangeal portion of the fingers is swollen, the nail wide, curved, striated and brittle. The finger ends are often congested or cyanosed.

(2) *The Bone Lesions* The osseous lesions consist of symmetrical increase in size of the bones of the extremities, beginning with the distal bones—metacarpals and metatarsals, radius and ulna, tibia and fibula.

(3) *The Arthritic Lesions* There are intermittent attacks of swelling, pain and tenderness, and movements are painful. The swelling can be appreciated as due to increased thickening of the synovial membrane, which persists to some extent when the acute phase is past. In some cases true arthritis may supervene, and lead to fibrous ankylosis and deformity.

In addition, there is usually well marked muscular atrophy and general weakness. The former is in part due to the debilitating effect of the original disease and in part produced reflexly by the joint disturbance.

PATHOLOGY

The terminal part of the finger is swollen and enlarged. The nail is enlarged so that it overlaps its bed, while it is curved over the end of the fingers producing the so called parrot's beak effect. It is markedly striated and breaks easily. Under the nail there is a vascular turgescence and a hyperplasia of the connective tissue.

The joint lesions are the result of swelling and turgescence of the synovial membrane, which shows an infiltration with granulation tissue and with small round cells. Later there may be erosion of the articular cartilage, with exposure of the underlying bone.

The thickening of the bone is due to the deposit of successive layers of new sub-periosteal bone. The sub-periosteal sheath is loose and friable, and especially marked at the muscular or tendinous insertions. In long standing cases, especially when the individual is confined to bed, there may be marked atrophy of the cancellous tissue of the old bone. At other times, it is sclerosed and the medullary cavity may be encroached upon.

ETIOLOGY

Many theories have been advanced to explain the occurrence of these curious changes. Thus they have been attributed variously to bacterial toxæmia, amyloid disease, tuberculosis and neuropathy.

Phemister and others regard two factors as necessary for their production—the first a toxin from the long standing intra thoracic disease the second circulatory disturbances from cardiac and pulmonary involvement

Comipere and Adams have shown that the diseases which are associated with Marie's syndrome are all productive of dyspnoea cyanosis and a disturbance of the acid base equilibrium of the peripheral blood They point out that a toxic factor is not necessary—and often not present—as in carcinoma of the lung syphilis and hepatic disease These views are supported by two facts (1) Similar bone changes are occasionally encountered in those who for a long time live at high altitudes (2) in certain cases they studied the carbon dioxide content of the blood serum was increased and the oxygen content diminished

In Campbell's opinion oedema is the primary pathological basis in this disease He believes that the diseased area through which the blood flows prevents proper ventilation and accordingly the oxygen tension of the whole arterial blood will be lowered The transference of oxygen from the blood to the tissues depends on the difference in tension of the oxygen in the blood and in the tissues It will be clear that if from any cause the arterial oxygen tension be lowered the tissue respiration will be defective A small defect in tissue respiration may not produce any demonstrable effect on the individual but if it does this will be seen in parts of the body where the defect is increased by a slow circulation These parts owing to mechanical reasons are the tips of the fingers and toes and the nose This imperfect oxygenation or anoxæmia of the parts produces oedema and later if long continued it may be hypertrophy of the connective tissue

CHAPTER VIII

CHRONIC ARTHRITIS

Chronic arthritis a disease which probably has more synonyms than any other is for various reasons one of the most serious of all joint affections. Its economic importance is reflected in the recent statement that each year it is responsible for the loss of more than one and a half million weeks of labour in America and that annually it costs the Approved Societies nearly a million pounds in insurances. Its treatment bulks largely in the work of the orthopaedic surgeon to whom are referred those whose lives have been made a burden through pain or crippling. The disease has therefore a profound significance and there is a vast field for research in the question of its etiology and treatment. Chronic arthritis is as old as man himself—it has affected both man and the lower animals from remote periods in the earth's history and in the Museum of the College of Surgeons there are ancient Egyptian bones which exhibit all the changes which we have come to regard as typical of the disease.

Nomenclature The Committee appointed by the British Medical Association in 1931 has adopted the following clinical grouping

RHEUMATOID ARTHRITIS

Synonyms Chronic polyarthritis (Continental nomenclature)
Atrophic Arthritis (Goldthwaite)
Proliferative Arthritis (Nichols and Richardson)
(American nomenclature)

Primary cause unknown with further knowledge this may merge into

Secondary associated with focal or general infection

CHRONIC VILLOUS ARTHRITIS

Mainly occurring in women at or about the climacteric

OSTEO ARTHRITIS

Synonyms Hypertrophic Arthritis (Goldthwaite)
Degenerative Arthritis (Nichols and Richardson)

Primary no definite association with infection

Secondary associated with infection

The first group polyarticular and more common in females may begin either in childhood when it is known as Still's disease or in early adult life—usually before the age of 40—when it is called rheumatoid arthritis. The joints are swollen and though X ray examination shows

little or no bone destruction the patient may be completely disabled by the disease. Anæmia and pallor are common, and enlargement of the lymph nodes is a frequent occurrence.

The second group is that which affects middle aged women who are inclined to be florid and stout, and who show signs of some thyroid deficiency. It has hitherto often been known as "menopausal" arthritis.

The third type of chronic arthritis is that which affects older persons, and which has been variously known as osteo arthritis, hypertrophic arthritis, and destructive arthritis. This is a more chronic form. There is often stiffness of the hip, and stiff, painful, creaking knees, and the victims limp about with the aid of a stick. The general health, however, is good, and the patient often volunteers the information that if it were not for his joints he would be perfectly well.

RHEUMATOID ARTHRITIS

PATHOLOGY

Primary and secondary rheumatoid arthritis do not present any significant differences in pathology one from the other. The following description, therefore, applies to both.

The disease begins with a round celled infiltration of the synovial membrane, most marked at the margins in the neighbourhood of the *circulus articularis vasculosus*. The synovial membrane and the perichondrium of the affected joint show a marked proliferation with the result that a layer, or pannus, of granulation tissue grows over the joint cartilages and destroys or absorbs them wherever contact is established. At the same time the activity of the perichondrium results in the formation of some new cartilage or bone. In the neighbourhood of the joint, the connective tissue of the marrow and of the epiphyses proliferates to form a vascular granulation tissue which extends up to, and may even ulcerate through, the overlying articular cartilage. The cartilage, therefore, may be destroyed either by the growth of granulation tissue from the marrow, or by the extension of granulation tissue over its surface.

Changes in the Bones. The bone trabeculae may be diminished in size and in number, and the density of the bone decreased by the absorption of calcium salts from its matrix.

Changes in the Capsule. The connective tissue of the capsule proliferates and the capsule is therefore thick, it is liable to undergo conversion into dense fibrous tissue, so that movement at the joint may be seriously hindered.

Changes in the Joint. When the articular cartilages are destroyed by granulation tissue, fusion occurs and the resulting ankylosis may be fibrous, cartilaginous, or bony, according to whether synovial, perichondrial or the trabecular proliferation predominates. If the trabecular

proliferation is excessive, all traces of the original joint are obliterated, and the compound bones are completely united, often with a single continuous medullary canal. Limitation of joint movement in this form of chronic arthritis is usually due to a degree of ankylosis, in contrast to the osteoarthritic type, where restriction of movement is usually due to the deposit of extra articular osteophytes. Associated with the tendency to ankylosis, there is a tendency for dislocation or subluxation to occur.

ETIOLOGY

No definite cause has yet been ascribed to this disease. There are, however, two main schools of thought, which regard it as an infective and as a non infective process, respectively.

Non-infective Theories. The non infective factors which are held to contribute to the production of rheumatoid arthritis are

- 1 A congenital predisposition
- 2 Endocrine disturbances
- 3 Gastro intestinal derangements

Little evidence can be adduced in support of the first two of these factors, but derangements of the alimentary tract are occasionally found. These might almost be considered as infective factors since they are commonly inflammatory in nature and often situated in the right iliac fossa. These chronic intestinal disturbances are apt to lead to constipation or stasis, and the delay so caused may encourage the elaboration and absorption of toxins which ultimately are conveyed to the joints. In some cases the actual organisms which are present in the bowel may be borne to a similar destination.

Pemberton has recognized for many years the relation of gastro-intestinal disturbances, as determined by X rays, to the arthritic syndrome, and the importance of dietetics in its treatment. The disturbances of the gastro intestinal tract include dilatation of the bowel, achlorhydria, atony of the gall bladder, and general visceroptosis. In these conditions can be seen the influence of faulty body posture which favours and induces mal position of the thoracic and abdominal viscera. Such mal positions in turn increase the faulty posture of the body, and so a vicious circle is established.

The Infective Theory. The infective theory is widely held and there is much to be said in its favour. It may be that organisms from some distant focus reach the joint and initiate the series of changes which characterizes the disease, or it may be that the joints have become hypersensitive to the presence in the blood of any circulating toxin which is being fed into the circulation from an obscure infective focus such as a septic tooth apex. Be that as it may, the clinical course of the disease—where joint after joint is affected, swells up and becomes red, hot and painful, and then settles down—is much more characteristic of a septicæmic than of a toxic infection.

Rosenow, in 1914, first suggested that examination of the lymph

glands at the root of the affected limb might offer some suggestive evidence, and this was borne out by the isolation from the deep inguinal glands of active micro organisms in a number of cases of rheumatism. Adam found a small gram positive pleomorphic organism which tended to occur in pairs, was non motile and slow growing and resembled a diplococcus. It was also a facultative anaerobe. On whole blood agar, colonies appeared only from the fifth to the ninth day after inoculation. Baird, on the other hand, has obtained a growth of streptococcus haemolyticus from the lymphatic glands in a case of rheumatoid arthritis. A vaccine elaborated from this streptococcus and exhibited to the patient led to a rapid subsidence in his acute symptoms. The isolation of these organisms is by no means easy, but Baird insists that success depends on the manner in which the culture is grown. By his special methods he obtains a culture in 75 per cent of cases from the glands of the affected area, but the colonies appear only after two or three weeks. The usual invader is a non haemolytic streptococcus, to a lesser extent the haemolytic streptococcus occurs. In one or two of his cases a staphylococcus was present, and in one case a gonococcus was found both in the knee itself and in the glands. Baird states that "Rheumatoid arthritis, to my mind, will represent an equation thus: Infection + x = Rheumatoid arthritis. The significance of the unknown factor (x), or its nature, we do not know. It may be called 'allergy'. Perhaps it is associated with glandular internal secretions. There may be many factors. I think, however, we are pretty nearly at the place where, if we limit the infection, we arrest the arthritis, whatever the other terms of the equation may be."

Shand aspirated eighty five joints and made inoculations of the fluid, of this number twenty six, i.e. 30 per cent, showed positive cultures. In five cases an organism similar to that discovered in the infected joint was also recovered from the glands at the root of the limb.

The influence of infections of various types in precipitating a certain proportion of cases of arthritis is thus very clear cut. Many organisms apparently can initiate the disease, but it is probable that the streptococcus is the most frequent offender though no single strain has assumed as yet the chief role in those cases which are of infectious origin.

One of the interesting facts brought out by recent studies is the marked influence of heredity in the production of arthritis. This does not mean that the disease is inherited *per se*, but it does mean that the background upon which the disease is implanted is definitely inherited in about 50 per cent of all cases.

It has long been recognized that those with arthritis often suffer from coldness and blueness of the hands and feet, but the true explanation is only now forthcoming. Exposure to cold shows that when the utrial peripheral temperature is lower, the subsequent fall of temperature is also less. When the subject returns to room temperature, the rise in the lowered peripheral temperature is also slower and

less than in normal individuals. This is due to a condition approaching rigidity of the finer peripheral vessels because it is known that, other things being equal, the temperature in a part is regulated by the blood flow through it. Again direct observation of the capillaries under the microscope shows them to be more or less closed, or at least empty, in the arthritic. It thus appears that the rheumatoid syndrome is accompanied by a disturbance of peripheral vessels suggestive of vasoconstriction.

This is in keeping with the clinical observations of the frequency with which Raynaud's syndrome is encountered in the rheumatoid case, and fits in well with the long recognized clinical effect of certain remedial measures used in arthritis, namely heat and massage.

CLINICAL FEATURES

The disease is usually poly articular, but may be mono articular and



FIG 191.—Rheumatoid Arthritis of Joints

Case showing multiple infection of joints.

any joint, whether large or small, may be affected. It is commonest in early adult life, but may arise at any age.

The onset may be acute or it may be insidious. The first sign is often stiffness or lameness which gradually increases. Although often mono articular at first it may spread to involve practically every joint in the body. The characteristic local changes are swelling and effusion and the joint capsule becomes thickened. X-ray examination shows increased permeability of the bones in the neighbourhood of the joint, as a result of the loss of lime salts.

After an acute attack there is a persistent slight deformity and some limitation of movement in the affected joints. These disabilities increase with each exacerbation until there may be gross distortion or even dislocation of the joints. Adhesions form between the opposing articular surfaces and they may be so dense that the joint cavity is obliterated and movement impossible. Albee has summarized completely the various

clinical manifestations that may occur. These are stiffness or lumpiness, localized sweating of the hands and feet, decrease in the surface temperature, deformity, with flexion or subluxation, pain, at first slight, crepitus, limitation of motion, with ultimately apparent ankylosis of varying degree and form, constitutional derangements, lassitude muscular atrophy, enfeebled circulation, sallow, thick, and dry skin striated, hypertrophied or exfoliated nails. The facial expression bears eloquent witness to the chronic distress of body and mind.

Henderson and Adson divide rheumatoid arthritis into three groups

(1) *Advanced and accompanied by ankylosis*

(2) *Less advanced and pain a pronounced feature*

(3) *Vascular disturbances pronounced*

(a) *Vaso spastic phenomena of Raynaud's disease or thromboangitis obliterans*

(b) *Cases where pale, cold clammy extremities precede or accompany the arthritis*

DIAGNOSIS

The Arthritis Committee has pointed out the importance of differentiating between rheumatic infection of acute or sub acute nature and rheumatoid arthritis. A useful table for differentiating the conditions is published in its report and is printed here in a modified form.

| | <i>Acute Rheumatism</i> | <i>Rheumatoid Arthritis</i> |
|-------------------------|--|--|
| Incidence | Chiefly adolescents and young adults of both sexes | Women of child bearing age (at least in the primary form) |
| Onset | Acute | Subacute (sometimes the two conditions are practically indistinguishable in the early stage) |
| Joints affected | Flitting from one joint to another, complete recovery of individual joints | Small peripheral joints with bilateral symmetry, persistence of changes after acute stage has passed |
| Skin over joints | Red and hot | Shiny, cold. |
| Pain and tenderness | Severe, very tender | Not severe, slight tenderness |
| Swelling | Due to synovial effusion | Slight, periarthritic |
| Pyrexia | May be present and is sometimes high | Not marked, occurs initially and/or intermittently thereafter |
| Cardiac involvement | Common, may be severe and permanent | Frequent tachycardia, but permanent lesions are rare |
| Spleen and lymph glands | Not enlarged | Not infrequently enlarged |
| X ray | No change | Local or general osteoporosis. |
| Response to salicylates | Satisfactory | Analgesic effects, but only temporary |

PROGNOSIS

The prognosis should be guarded as the cartilage has but little power of regeneration, and even when it proliferates the deformity tends to increase. The outlook in a sense depends upon the elucidation of the cause, and, when a bacterial source has been discovered upon the individual's reaction towards serum or vaccines. Some of the cases go rapidly downhill in spite of all treatment and permanent fixation of the joint may occur usually as a result of bony ankylosis.

TREATMENT

The treatment may be considered as medical, surgical and orthopaedic but the rigid adoption of any one type is not in the best interest of the patient. *Effective treatment should combine the best remedial measures of all three*



FIG 192—Rheumatoid Arthritis of the Wrist



FIG 193—Rheumatoid Arthritis of the Hand
The typical appearance of the hand

groups. The first obligation is to institute a thorough search for any possible infective origin. The teeth should be carefully investigated by a competent dental surgeon, and infected teeth extracted. The nose, throat, the tonsils, and the air sinuses should be carefully

overhauled and foci of infection or of suspected infection eradicated or treated

The abdomen should be thoroughly examined. The possible sources of infection there are the appendix Fallopian tubes the gall bladder the intestine (stasis) the genito urinary tract the seminal vesicles and the prostate. The whole problem of intestinal infection and toxæmia is obscure however and excepting the removal of clearly infected cul de sacs such as the gall bladder or the appendix conservative measures are invariably adopted. These consist of careful dieting and proper evacuation through the agency of laxative remedies. Promises of relief by removal of foci should be as conservative as the removal itself should be radical.

The preliminary investigation should conclude with examination of the blood the urine the stools the endocrine glands and general condition of the patient. Syphilis should be excluded by investigating the Wassermann reaction. Finally in view of the interesting work of Beyer and Shand it may in certain instances be desirable to remove one of the glands at the root of the limb for bacteriological examination and if possible the manufacture of a vaccine.

Diet The nutrition of the patient must be thoroughly investigated since most of these arthritic patients are under nourished and anæmic. In the badly nourished type appetizers are given the diet should be rich in all vitamins cod liver oil is advised and liver or liver extract may be given. The arthritic individual requires 100 to 200 mg. of Vitamin C daily i.e. two or four times that needed by a normal person and it is probable that an ordinary hospital diet is inadequate in ascorbic acid.

On the contrary in the fat plethoric type of arthritics we must reduce the intake of nourishment. Fluid intake is restricted and a diet poor in salt content and rich in carbohydrates only in the form of bread or gruel is given. In both cases plenty of fruit and fresh vegetables should be included in the diet.

Physiotherapy Prolonged physiotherapy by trained physicians or physiotherapists is beyond the means of the majority of patients. The method is of distinct value however and the above disadvantages may be partly overcome by instructing the patient himself to carry out a daily programme of physiotherapeutic treatment which can be supervised periodically. The measures of greatest value are hot and cold compresses contrast baths and showers simple yet specific exercises and if necessary hot sand or salt bags. For the more fortunate or the more desperate patient a prolonged stay in a warm equable climate is indicated but that too is usually more palliative than curative.

Vaccine Treatment Autogenous vaccines theoretically potent are generally disappointing. If their alleged specificity is confirmed by positive results from animal experimentation they would seem to be justified. Henderson and Hench believe that in spite of a percentage

of failures, and in spite of unpleasant reactions, typhoid vaccine administered intravenously gives justifiable results in a proportion of cases.

Medical Treatment No specific medical treatment has yet been described for infective arthritis. Analgesic medicines should be given liberally to relieve the pain, and because of their psychotherapeutic effect. French tincture of iodine may be employed in doses up to 7 minims three times a day. Estrin injections may benefit some cases, especially those with scanty periods or amenorrhœa. Hydrochloric and arsenical preparations are indicated for the achlorhydria and anæmia which are often associated with the joint condition. Intestinal antiseptics are ardently advocated by some authorities. Cottrell treated twenty-one patients with orthoiodoxy benzoic acid, and obtained improvement in all but three cases. The relief of pain was prompt and marked. The drug is administered intravenously twice weekly for three or four weeks, with an interval of three to six weeks' rest between each course. The drug may also be given orally, in capsule form. The proprietary preparation, Arthrytin, is similar to the orthoiodoxy benzoic acid.

Treatment by Gold Salts Gold preparations were introduced into the treatment of chronic rheumatism by Forestier of Aix les Bains. They are one of the best medicaments for this condition.

They are especially indicated for chronic arthritis with a more or less distinct infective contributory factor, streptococcal or tubercular, and for lesions of the rheumatoid type. As gold is powerful it is contra-indicated in patients with great weakness, intense anæmia, cachexia or lack of reaction.

The mode of action of gold, or more precisely the gold sulphide preparations in use, is problematic. They seem to stimulate immunity organs to the production of antibodies against the infective and toxic elements present in the chronic rheumatic. There are grounds for believing that their action takes place through the reticulo-endothelial system. Gold injections produce an artificial disease, gold disease more or less similar to the "rheumatic disease". Their action can thus be explained in the light of modern immunological principles.

The most important preparations used are

Sanocrysin, a thiosulphate of sodium and gold, the preparation originally used by Moellgaard in the treatment of pulmonary tuberculosis,

Allochrysine, aurothiopropyl sulphate,

Solganal, an aurothioglucose, ranking with sanocrysin as probably the most practical preparation.

In chronic rheumatism oily preparations have proved best (oil of sanocrysin, solganal B oleosum), the degree of tolerance of gold being increased by suspension of the metal in oil. These preparations can be injected intramuscularly, forming a deposit in the muscle. As

rule absorption is more gradual and the effect more protracted and uniform by this method and secondary effects are lessened. Only intramuscular injections should be given in chronic rheumatism.

Dosage is important both in the matter of the individual dose and of the total given in each course. The drug has its complications the chief of which are toxic gold rashes, buccal ulceration, albuminuria, diarrhoea and less rarely purpura and jaundice. The employment of excessive doses has been incriminated in the production of agranulocytosis. The initial dose should not exceed 0.02 gm. and the dose should be worked cautiously up to a maximum of 0.1 gm. The doses are given at weekly intervals and a course of 10 gm. is given. The onset of complications may interrupt the full course. Arthritic patients are more sensitive to the drug than tuberculous patients and the dosage must be a more cautious one.

Severe reactions are said to be lessened by giving 10 c.c. of a 10 per cent solution of calcium gluconate with the gold solution. A severe reaction is not to be regarded as a contra indication to continuation of treatment at a later stage as it is said that 70 per cent of the patients who have reactions in the first course have no further trouble in a later one.

A second and in some cases a third course may be given the indications for repeating the course depending upon the patient's condition and progress. It is important that an interval of not less than six weeks should intervene between each course to allow complete excretion of the metal to take place.

Examination of the blood is particularly important for controlling treatment. Decrease in white blood corpuscles and decrease in blood sedimentation rate particularly the latter are significant indications for reducing the dose.

The clinical results of gold treatment have amply confirmed the work of Foréster. He claims cure or improvement in more than 60 per cent of a series of 500 cases treated and somewhat similar results have been given by other writers. The general condition improves. Patients who were pale and cachectic show normal colour, look stronger and less depressed. The inflammatory condition of the joints improves and in favourable and recent cases it disappears. In older cases it is usually very much alleviated. Foréster gives observations of patients who had been bedridden for four to six years but were able to stand and walk a few steps after the first series of treatment. There is a very distinct action on pain shown by the fact that these patients decreased the quantity of aspirin they were taking.

Local Treatment. *Rest.* When joint irritation is present with muscular spasm and pain rest is necessary. In the acute stage the patient should be placed in bed with traction applied to the affected limb. It is important to bear in mind that there is a strong tendency to early and rapid ankylosis so that a careful compromise must be made between rest and movement. This problem is best

solved by allowing the patient non weight bearing movement, as regards joint function this is just as useful as weight-bearing motion but is much less harmful. The movements must never be carried to the point where they cause pain.

Immobilization Since rheumatoid arthritis is essentially inflammatory and the disease in the joint consists of a spread of pannus across the cartilage and granulation tissue deep to it, Dr Vincent Coates believes that the more rest allowed to such a joint the more prospect is there of arresting such a process. On this basis he has suggested that absolute immobilization in plaster of Paris would help to heal such joints.

Kindersley states that the effect of the plaster is that locally it relieves pain, allows subsidence of the inflammatory process and absorption of effusions, its general effects are the comfort of the immobilization which produces sleep without sedatives, an improvement in the general health, and a relief of spasm. The coarse tonic spasm of the muscles which goes on night and day is controlled and the muscles are rested and allowed to regenerate. The plaster prevents deformity and in certain cases may be used to improve any deformity present.

It is obviously quite impossible to splint every joint in the body and in practice this is found unnecessary. The joints which give rise to severe pain and are rested with the greatest difficulty are the knees, ankles and wrists. This means applying one long plaster to each leg and a small light plaster to the forearm and wrist.

A skin tight plaster is applied and from two to twelve days after the application the plaster is hivalved, and as soon as possible the patient is given the usual general treatment, especially deep hot baths. After the physiotherapeutic treatment the patient goes straight back into the splint and the muscles are massaged on alternate days. After two to three deep baths the joint is allowed free for half an hour and then returned to the splint. Heat and swelling, particularly heat, are the indications for prolonged rest in the splint.

In cases where fibrous adhesions have formed, and the joint has become stiff in bad position, it is sometimes possible to restore a certain amount of mobility by skilful manipulation. The adhesions should be gradually stretched each day, the manipulation being carried out with the greatest care lest a recrudescence of the disease be precipitated.

Operative Treatment.

Adson and Rowntree have obtained surprising results in chronic arthritis by the resection of the lumbar sympathetic ganglia. Generally speaking, the muscular tone and calibre of the arterial system is governed chiefly by the sympathetic nerves. The sympathetic nervous system also conveys sensory fibres which have their ganglia in the spinal cord. Orbeli believes that the relief of pain following sympathetic denervation is due to lowering of the sensitiveness to pain. A Young suggests that the augmentation of the blood supply might be the chief

factor in causing improvement. The cases of chronic arthritis selected for ganglionectomy are those in whom the disease is progressive and who have failed to respond to the accepted types of treatment such as the removal of foci of infection, immobilization, massage and exercise and who present the vaso spastic syndrome that is temporarily relieved by radiant heat, diathermy and vaccines. Pemberton also believes that ganglionectomy offers a rational method of influencing the circulatory vasoconstrictor disturbances occurring in young persons with soft arteries. He thinks it important that the surgical procedure should be instituted early in the course of the disease before bony changes have taken place in order to obtain the maximum results from the operation. F. A. Bothe suggests that ganglionectomy is most beneficial in the third group of arthritis—those with prominent vascular disturbances—and though it may help some in type 2 it is of little use in the first group.

These operations on the sympathetic system are fully described in Chapter XII.

The usual operations employed in the treatment of rheumatoid arthritis are mainly directed to the correction of deformity. Since deformity is most serious in the lower limbs where it interferes with walking it is there that operative intervention has its chief sphere of usefulness. Operation should not be hastily undertaken for many of the deformities can be improved gradually by mechanical means.

Contracture of the Knee. This flexion deformity is exceedingly crippling especially if bilateral and is none too easy to treat successfully but cases can often be greatly improved either by a plaster of Paris method or by a combined traction method.

In all cases the extension must be gradual, forcible manipulations are dangerous and should always be avoided. In old subjects even gradual methods such as traction are often attended with considerable danger to life.

(a) *By means of a plaster of Paris cast.* This is applied from and including the foot up to the upper thigh and adequately padded with felt over the front of the knee and the back of the foot and thigh. When firmly set the plaster is cut three quarters way round at the level of the knee joint leaving only a quarter of the circumference intact in front of the joint line. A screw instrument is then inserted into this cut behind and screwed gradually slowly and every day so that the two halves of the plaster are separated behind the knee and being hinged in front by the intact plaster the leg is gradually straightened.

(b) In severe cases the above method may prove inefficient and simply straighten the leg at the expense of producing a posterior dislocation of the head of the tibia. In these cases it is better to employ a double skeletal traction by Hirschner's wires. One wire is introduced through the head of the tibia and is made to pull forward as well as

downward, while the pull of the second wire through the malleoli or os calcis pulls more directly in a distal direction

Measures designed to correct deformity must never be undertaken during the acute progressive stage of the disease. In such cases more is to be gained by attempts to extirpate the diseased joint in its entirety and by carefully considering the apposition of the bony surfaces to give the patient a painless stable limb

Surgical procedures should not be undertaken until at least six months after the activity of the disease has ceased and the patient is in good condition and able to co operate and afford prolonged treatment and until proper nursing care and physical therapy are available. Multiple operations in stages and a well planned campaign of reconstruction are required

The following operations are employed

1 Osteotomy When deformity at the hip or the knee is too great to be corrected by manipulation or by traction then a wedge osteotomy may be performed. In the knee at certain stages of the disease the patient may have 10 or 15 degrees of movement in the joint but since the joint is in a position of flexion such a range is inadequate to secure extension and the function of the joint is bad. A wedge osteotomy at the lower end of the femur will so alter the functional position of the joint that full extension will be possible in addition to 15 degrees of flexion (Fig 203). A wedge osteotomy combined with tenotomy of the adductors may be used similarly for flexion adduction deformities of the hip. When both hip joints are ankylosed a pseud arthrosis on one side and an osteotomy on the other will often improve the function to a considerable extent

2 Excision of the Joint When there is extensive disease in both knee joints with destruction of the articular cartilage as shown by X ray or with flexion deformity and pain on movement it is wise to excise one joint and give the patient a painless stable weight bearing limb

The operation is carried out through a U shaped incision extending from the adductor tubercle on the medial side to a corresponding point on the lateral side of the lateral condyle. The apex of the flap should embrace the tibial tuberosity. The patellar tendon is divided and the flap containing the patella reflected upwards to expose the whole joint cavity. The remnants of articular cartilage the cruciate ligaments and the semilunar cartilages are shaved off until healthy bone is exposed. The opposing surfaces of the tibia and the femur are then approximated and held together by pins driven upwards into the femur from either side of the head of the tibia. A tourniquet is never employed in these operations and it is therefore desirable that a firm dressing be applied immediately after the operation to prevent any undue oozing of blood

The leg is put up in a plaster case extending from the toes to include the pelvis. This is removed in six weeks when the pins and

stitches are removed and a skin tight case substituted. This case is retained for about three months. An X ray film is then taken and if union is not yet solid a further plaster is applied from the adductor region down to and including the foot. The joint surfaces should not be fixed in an absolutely straight position. ankylosis in a position of slight flexion about 5 degrees is preferable as it prevents the formation of a genu recurvatum later. Unfortunately it increases the shortening of the limb but this is no disadvantage when the other limb is already short as a result of flexion deformity.

3 Synovectomy Excision of the synovial membrane may also be employed. It is useful in cases of sub acute synovitis with local tenderness pain on movement stiffness and effusion. The operation is also of value in chronic gonococcal arthritis with sub acute synovial changes. Allison indeed says there are few contra indications to this operation. Pain and discomfort are greatly relieved the function is improved and marked improvement occurs in the other joints infected. Age poor general condition and hopeless inactivity therefore are not contra indications. Allison has operated on subjects who have been bed ridden for years and found that they tolerated the operation well improved in every way and were finally able to walk. The operation is rarely carried out other than in the knee joint.

Technique A tourniquet is applied and the joint opened through a parapatellar incision the patella being dislocated laterally. It may be possible while the joint is actually being opened to separate the synovial membrane from the capsule along the line of the incision. The infra patellar pad of fat is divided its lateral half seized with heavy clamps and the synovial membrane dissected free from the deep surface of the patellar tendon and the head of the tibia. The lateral semilunar may be removed entire or left in situ. The lateral pouch of the joint is stripped of synovial membrane up to the border of the patella and the lateral aspect of the femoral condyle also cleared. The supra patellar pouch is similarly stripped and the separation continued over the medial condyle of the femur to the medial pouch of the joint. The medial semilunar may or may not be removed. The space between the femoral condyles and the two cruciate ligaments is now cleared. The entire joint cavity is carefully wiped with gauze to remove any loose vestiges of the membrane. A firm dressing is applied and the tourniquet removed. The knee is supported in suspensory slings and kept at rest for about forty eight hours. Thereafter joint movement is encouraged and radiant heat massage and exercises commenced. Functional use of the joint should be encouraged as soon as possible.

According to Allison the improvement constantly noticed in cases of polyarticular rheumatoid arthritis is most striking. The explanation is doubtful and the improvement in the present writer's opinion inconstant. He performed synovectomy in several cases of rheumatoid arthritis but in only one was there any improvement. In that case

the amelioration was probably due to the removal of a large mass of diseased tissue which must have been liberally feeding toxins into the circulation. The author in view of the uncertainty of its effects does not feel justified in merely performing synovectomy if operation is undertaken at all the evacuation of the diseased tissue is supplemented by an arthrodesis.

CHRONIC VILLOUS ARTHRITIS

This type of arthritis occurs mainly at or about the menopause in women of almost invariably florid and stout build. They may also show signs of thyroid deficiency such as thinning of the hair and eyebrows and thickening of the subcutaneous tissue about the shoulders and hips.

The early symptoms are pain and stiffness usually in the knees and often worse during rest. These symptoms increase and walking becomes difficult especially on rough ground. Pain and tenderness when present appear to be worse on the inner aspect of the joint which in the early stages shows only some slight swelling with fine crepitation on movement. As the synovial membrane becomes thickened the swelling is more pronounced and can be noticed below and on each side of the patella. When the knee is extended a tense swelling may be felt and seen in the popliteal space due to distension of a synovial pouch. Muscular wasting comes on in the later stages. As a result of defective muscular tone and increasing weight flat foot occasionally develops. Heberden's nodes are occasionally found in this disease but there is no evidence that they share with it a common cause. X-ray examination may reveal nothing but often there is slight erosion of the cartilage or slight new bone formation at the joint margins.

MORBID ANATOMY

The synovial membrane in those cases which have been examined is found to be thickened and congested with an increase in the number and size of the fringes hence the name villous arthritis. Microscopically there is an increased number of small blood vessels and a perivascular small celled infiltration. In some cases these changes progress to typical osteoarthritis.

PROGNOSIS

With adequate local and general treatment the prospect is favourable.

TREATMENT

If the symptoms are very acute complete rest and immobilization are indicated. In less severe cases partial rest and a bandage with perhaps a light posterior splint may be sufficient. Diathermy short

wave therapy radiant heat, and local douching are helpful. Any existing deformity of the foot must be corrected and varicose veins if present are treated. General measures include thyroid medication, and agencies for the reduction or prevention of obesity, with sedatives if pain is severe.

OSTEO ARTHRITIS

This disease is characterized by primary degenerative changes in the articular cartilage and subsequent new bone formation at the articular margins. The larger joints are those usually affected, with the hands and feet sometimes affected as well. The disease occurs



FIG. 194.—Osteo Arthritis

A dry specimen of an advanced case showing the bipping formation of osteophytes and the deformity

in the middle aged and elderly, who although healthy in other respects often show evidence of arterial and other degenerations.

ETIOLOGY

The etiology of this condition may be discussed under the following headings:

(a) Local Causes

(1) Previous trauma—fractures involving the joint, dislocations, occupational strain, altered articular alignment from disease, joint mobility from relaxation of ligaments.

(2) Nutritional bone diseases in infancy—Coxa Vara, Perthes disease, rickets.

(3) Congenital dislocation of the hip especially after forcible manipulations.

(4) Errors in local blood supply of the joint as after aseptic necrosis of the head, osteochondritis dissecans

(5) Subacute infections of the joints in earlier life, as rheumatoid arthritis

(b) *General Causes*

(1) Generalized toxæmia from localized foci of infection

(2) Diseases interfering with the nerve supply of the articular spaces

Idiopathic senile osteo arthritis might also be included in this group, the trauma—if it can be so called—is that of deficient nutrition due either to endarteritis obliterans of the nutrient vessels or to alterations in the

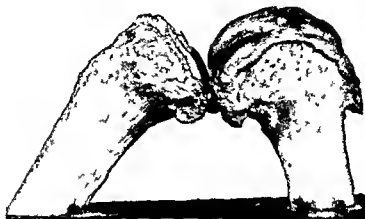


FIG. 130.—Osteo Arthritis of the Knee
Dry specimen showing the hopping deformity etc

quality of the synovial fluid following arterio sclerosis of the capsular vessels

PATHOLOGY

The primary lesion in osteo arthritis consists of degeneration of the hyaline cartilage. As a result, the cartilage is soft and is easily and rapidly eroded until ultimately the bone ends are exposed. The erosion of the cartilage is not uniform, so that at first areas of bone are exposed in a patchy fashion and there are intervening islands of normal cartilage. The process gradually becomes more comprehensive, until finally the bone-ends are entirely denuded, but the process is so slow that joint movement is maintained for a considerable time. The perichondrium and the cartilage round the periphery of the joint are stimulated into activity, and, as a result, the non articular areas of the bones are heaped up and elevated above the remainder of the surface, and project circumferentially to give the appearance known as "hopping". In addition, irregular outgrowths appear in this area, at first cartilaginous, but eventually becoming ossified to form osteophytes.

The synovial membrane is involved in the later stages, and is the site of an irregular shaggy proliferation. The synovial tags or polypi are insinuated into the joint and when very exuberant the process is referred to as "*lipoma arborescens*". Occasionally cartilage formation occurs in these tags and they are then liable to be broken off into the joint when they are known as "joint mice". The exposed bone ends of the articular surface are subjected to considerable friction, in consequence the bone trabeculae in the immediate neighbourhood are thickened and the marrow spaces obliterated. The change involves only a thin layer abutting on the joint and when the surface of this layer gradually becomes more and more smooth and polished as a result of the continual rubbing the process is known as eburnation.

An osteo arthritic joint rarely if ever becomes completely ankylosed, in contrast to the rheumatoid form in which ankylosis is almost the rule. Nevertheless the gross peripheral proliferation and the presence of osteophytic outgrowths may to a great extent impede the free movement of the joint, and even simulate a degree of fusion which does not in fact exist.

Changes in the Individual Joint Constituents

1 The Articular Cartilage The differing reactions of the peripheral and central portions of the cartilage referred to above, have been shown by Fisher to have a definite anatomical explanation, he has shown that between what he has called the central and the lateral areas there are differences in structure, in nutrition and in function.

(a) *Central Area* The central or articular area is poorly nourished and normally subject to considerable pressure. It responds to the disease by undergoing fibrillar degeneration, and true fibrous tissue may actually be formed although Fisher believes that the matrix of the cartilage proliferates without showing fibrous metaplasia.

The surface of the cartilage is roughened, a series of invading columns of osteoblasts penetrates the deeper layers and leads to a deposit of new bone and the cartilage cells overlying these inroads proliferate to form little cartilaginous projections on the surface. These are known as '*Ep articular ecchondroses*'.

(b) *The Lateral Area* The more liberal nutrition, and the absence of any gross degree of pressure allows a certain amount of proliferation in this area. The new cartilage is derived really from the synovial perichondrium and since it is actually in the joint it leads to an increase in the breadth of the joint surface. Later ossification of this hypertrophied cartilage leads to the characteristic lipping.

2 Changes in the Capsule These are slight. The fibrous tissue of the capsule becomes more dense and, at its point of attachment to the articular margin, may even be transformed into fibro or hyaline cartilage. In some cases bony nodules appear under the surface of the synovial membrane and project into the joint cavity. These

nodules may be sessile or pedunculated in the latter event they may be broken off to form joint nuce and may then cause the joint to lock or otherwise interfere with the free mobility of the joint

3 Changes in the Synovial Membrane The synovial membrane rarely shows any pathological change until the first signs of lipping appear. The membrane then appears thickened the villi already present are enlarged and new villi are thrown out. These projecting villi may become the seat of cartilage formation or become infiltrated with adipose tissue

CLINICAL FEATURES

The traumatic form of osteo arthritis is monoarticular and usually but not invariably affects one of the large joints the infective or toxic form on the other hand may be mono or polyarticular and frequently starts in the small joints of the hands and feet.

The onset is slow and insidious and the disease is seldom associated with a rise of temperature or with marked constitutional symptoms. The earliest symptom is stiffness experienced after rest and disappearing on movement. At this stage a soft creaking can be felt and heard. Pain gradually appears and the joint becomes swollen. There is an effusion not only into the joint but commonly also into the bursæ which communicate with the joint. After resting for a time the joint is extremely stiff and painful this is particularly noticed on rising in the morning. At this stage the joint outline may be more or less spindle shaped a feature most readily detectable in the joints of the fingers. The enlargement is roughly symmetrical and is most apt to affect the metacarpo phalangeal joints. After a variable period the articular margin may show a greater or less degree of lipping at first the out growths are cartilaginous and may not be apparent on x ray examination but a crunching or muffled kind of crepitus can be elicited when the joint is moved. Later when the central part of the articular cartilage has been eroded and the bone is exposed the symptoms become



FIG. 196.—Osteo arthritis of the Right Knee.

| Primary Rheumatoid Arthritis | | Secondary Rheumatoid Arthritis | | Chronic Villous Arthritis | | Osteoarthritis |
|------------------------------|--|--|--|--|--|--------------------------------|
| Incidence | Women of child bearing age | Any age either sex | Women at menopause | Both sexes in later decades of life | | |
| Onset | Generally sub acute | Sometimes acute | Slow and chronic | Slow and chronic | | |
| Infection | Not proven | Septic focus | Not proven | Not proven | | Present only in secondary form |
| Prodromal symptoms | Ill and emaciated | Absent | Absent | Absent | | Absent |
| | | Affected in later stages only | Ill and healthy | Tending to show signs of senile changes | | |
| General condition of patient | Small joints, tendency to spread centrifugally | Any joint distribution tendency to symmetry | I predominantly knees also 1st carpo metacarpal joints | Large joints especially hip | | |
| | | Enormous swelling, accentuated by wasting of surrounding tissues | Pouching swelling of knees | May be swollen more or less symmetrically in large joints, smaller joints tend to be nodular | | |
| Appearance of joints | Much restricted | Much restricted | Not much restricted | May be very restricted in some directions but free in others | | |
| | | Coarse cracking, or absent | Fine crepitation | Coarse grating | | |
| Muscular wasting | Marked | Variable | Absent | Marked in late stages only | | |
| | | Trophic changes | Myxodematous | Senile changes | | |
| Skin | May be severe | May be severe | Aching, not severe | May be very severe | | |
| | | Hypertrophic lichen common | Hypothyroidism | Tending to hypothyroidism | | |
| Lain | Rate increased | No constant change | Not affected | Arteriosclerotic | | |
| | | Rate varies with severity | No change till late stages when osteophytes may form | Areas of degeneration and osteophytes | | |
| Removal of septic focus | | Often improvement of the bones | No constant improvement | No constant improvement | | |

more grave. There is a constant gnawing pain and the patient feels as if the bones were being ground together as indeed they are. The peripheral outgrowths have now become ossified and these osteophytes may actually be palpable. Movement of the joint is associated with harsh grating and there may be unnatural mobility from ligamentous degeneration. The whole limb may be short or other deformities may be present.

Osteo arthritis can be more adequately controlled and is more amenable to treatment in its early phases than rheumatoid arthritis. The influence of trauma is very important and not sufficiently appreciated. Injury will serve to determine the onset of arthritis in a joint in individuals who already suffer slightly from generalized arthritis. For example an injury to the knee or the hip is likely to precipitate a troublesome form of arthritis in the injured joint. For this reason joint injuries in arthritic persons assume an unusual importance and should be prevented or efficiently cared for.

DIAGNOSIS

The main characteristics of the various varieties of chronic arthritis are well summarized in the Report of the Arthritis Committee of the British Medical Association as in the table on page 408.

DIFFERENTIAL DIAGNOSIS

A Charcot's joint and a tuberculous joint have certain points of similarity to the osteo arthritic but these conditions can invariably be excluded by a careful examination.

PROGNOSIS

The prognosis in osteo arthritis is governed by three factors.

(1) *The Cause of the Condition*: The correction of recognizable causes such as flat foot in osteo arthritis of the knees may completely arrest the disease. Gouty cases even with thinning of the cartilages often yield to spa treatment. When associated with arterio sclerosis the disease tends to progress.

(2) *The Joint Affected*: Morbus coxae senilis has a bad prospect though temporary relief is possible. Fixation of the joint provided a good position is secured is usually the best result obtainable.

(3) *The State of the Cartilages*: If parts of these have disappeared orthopaedic measures are required. With merely localized thinning correct splinting and local treatment may mean at least partial recovery.

TREATMENT

General Treatment

The general treatment follows the lines advocated for rheumatoid arthritis and it consists essentially of raising the body tone and stimulating the emunctory functions by baths rubbing and massage. The bowels should be kept open by laxatives and the kidneys kept active.

by liberal quantities of water with a low mineral content. There is no object in restricting the diet.

Numerous communications report favourable results with sulphur therapy in chronic arthritis and allied disorders. A colloidal preparation of sulphur is used and the one most popular is Sulphur Diasporal, made up in 2 c.c. ampoules for intravenous or for intragluteal injection.



FIG. 197.—Osteoarthritis of the Hand

tion. One injection, either intravenously or intramuscularly, is given weekly and the total number of injections is between 10 and 20. The patients usually show benefit after the third and before the tenth injection. A second course may be given after an interval of six months. The prompt and decisive response is most striking, and as a rule improvement is maintained after the cessation of sulphur therapy. No general reaction occurs with the intravenous method, but occasionally pain occurs at the site of the intragluteal injection. It is believed

that colloidal sulphur in many cases is a valuable adjunct to those measures commonly employed in chronic arthritis

Local Treatment

The affected joint should be rigidly protected from even the slightest of injuries and extremes of movement must be prevented since there is an ever present danger that one of the peripheral osteophytes or a synovial tag will be broken off into the joint. The joint how



FIG 198—Advanced Osteoarthritis of the Hip Joint

ever should not be completely immobilized. It is also essential to prevent deformity as the altered mechanics resulting from deformity throw added strain on related structures and may even precipitate the development of arthritis in other joints. This is particularly important in the hip joint where a flexion adduction deformity is liable to be followed by painful sacro iliac strain.

Deep X-ray Treatment Recently deep X ray therapy has been used in various forms of arthritis but particularly in osteo-arthritis occurring in middle aged people who appear to be in good health

otherwise. It is believed that much of the benefit is derived from the effect of the X rays on the vegetative nervous system, which plays such an important role in any anaphylactic reaction. The effect of the X rays on this system shows two stages. In the early stage, there is an exacerbation of symptoms lasting usually about forty



FIG. 199.—Osteo arthritis of the Hip Joint. Arthrodesis produced by removal of any cartilage from the joint surfaces and immobilization thereafter.

In this case a wire was inserted through the acetabulum and the femoral head.

eight hours but which may last one to two weeks. After this uncomfortable period there is the quiescent stage with amelioration of pain and improvement in the pain has been noted to last as long as six months after treatment. It is the author's experience that in certain of the joints, especially the superficial ones, e.g. the knee, some measure of relief with alleviation of severe symptoms can be promised by X ray therapy.

Surgical Treatment.

Active surgical measures are necessary in the presence of persistent pain and progressive deformity. The decision for or against operation is influenced by the number of joints involved. In cases where only one joint is seriously affected, and there is no general infection, then operation is certainly advisable, on the other hand, when the disease is polyarticular, operation is undertaken only after the infective process has become quiescent. The procedures which may be adopted in osteo arthritis include the following

- 1 Removal of villi or loose bodies
- 2 Synovectomy
- 3 Excision of the joint
- 4 Arthroplasty
- 5 Arthrodesis
- 6 Osteotomy
- 7 Cheilotomy
- 8 Joint debridement

1. Removal of Hypertrophic Villi and Loose Bodies. When a joint locks frequently, and later swells up and is painful, the obvious treatment is to remove the loose body. This is most often carried out in the knee joint, and less frequently in the other joints of the body. The technique of the operation is fully discussed in Chapter XV.

2. Synovectomy. This operation has already been discussed in the section on *Rheumatoid Arthritis*. It is rarely employed in the degenerative type of chronic arthritis, the indications for its use are the same as in the other form.

3. Excision of the Joint. The aim of this operation is to eradicate the disease completely. The unhealthy joint surfaces are removed in all cases, but the subsequent procedure depends on the object in view. In the knee it is well to aim at an arthrodesis, but in the other joints and particularly the smaller ones, such as the metacarpophalangea, a pseudarthrosis may be expected. After excision of the knee, therefore, the bones are fixed together by excision pins, in the elbow, hip, wrist, and the metacarpophalangeal joints on the other hand, sufficient bone is removed from each surface of the joint to ensure that the two raw areas will not come together and so become fixed. To make absolutely certain of this, it is advisable—especially in the metacarpophalangeal joints—to prevent further apposition of the joint surfaces by some method of traction during the immediate post operative period.

4. Arthroplasty. Arthroplasty is now being carried out more and more frequently, and no joint in the body can be said to be exempt from the efforts of the enthusiastic surgeon. Page holds that in osteo arthritis the operation is generally undesirable, on the grounds that the new joint may be presumed to undergo the same pathological changes as the original

5. *Arthrodesis.* *Arthrodesis of a joint consists of the removal of the remnants of the articular cartilage and of the underlying sclerosed bone, with subsequent approximation of the raw ends in good position. The ultimate result, therefore, is an ankylosis.* In a good number of cases in which an arthrodesis is attempted bony union does not occur, and then the resultant fibrous ankylosis, with its slight range of painless movement, is an even better result.

6. *Osteotomy.* Osteotomy may be required to correct deformity, particularly when the altered mechanical conditions are giving rise to pain. It is of particular value in connection with the hip joint.

7. *Chelotomy.* Chelotomy consists of the excision of the peripheral osteophytes. In many cases these are so prominent that they constitute a bony block which hinders movement. In this event their removal, in addition to lessening the pain, may increase the mobility of the joint considerably.

8. *Joint Debridement of Magnuson.* Magnuson believes this form of arthritis, produced by the wear and tear of life, progresses because of the presence in it of irregularities and roughnesses on the articular surfaces rather than any pathological condition of the synovia. He suggests, therefore, that the spread of the disease may be cut short by removing the roughened surfaces. He describes his operation on the knee, although it can be applied to other joints.

The knee joint is approached through a long vertical incision, and the patella displaced outwards. All roughened cartilaginous areas are removed with a thin osteotome from the articular surfaces and also adherent synovia and every trace of degenerated hyaline cartilage. This is so thoroughly done that in some parts the underlying bone may be completely uncovered. Transverse, though not necessarily longitudinal, ridges are removed. The after treatment consists of traction on the leg of 6 to 8 pounds for one week during which movements are encouraged. After ten days the patient is allowed to bear weight on his limb.

Magnuson states that unless the patient is anxious and willing to co-operate in the after treatment it is better that no operation be done as the result in such circumstances is likely to be unsatisfactory. This note of warning seems to imply some degree of pain in the convalescent stage.

ARTHRITIS IN THE INDIVIDUAL JOINTS

The Hip Joint

The hip joint is frequently the site of osteo arthritis, and the condition is sometimes spoken of as *malum coxae senilis*. It often follows an injury, possibly sustained years before. It is commonest in men past middle age.

PATHOLOGY

The joint space is diminished, there is irregularity of the two joint surfaces and hipping at the articular edges. The neck of the femur is broad and short, while it appears to have slipped upwards in relation to the head. The head itself is surrounded by a ring of osteophytes and appears to be much broader. The acetabular edge is also ringed with osteophytes and is rough and uneven, so that the acetabular cavity appears to be deeper. In the neighbourhood of the joint the bones show an increased density, and this is particularly noticeable in the weight bearing areas. The sclerosis is not uniform and the X ray shadow is mottled from the presence of areas of diminished density.

SYMPTOMATOLOGY

The usual complaint is of an ache in the hip, particularly in the early morning, and at the same time there is some limitation of movement. These gradually wear off in the course of the day but as the disease progresses they become more and more frequent. Later the most prominent feature is the deformity, at first the result of muscular spasm. The thigh is flexed and adducted, and the resulting shortening causes the patient to limp. The deformity has another effect, the sacro iliac joint is placed at a grave mechanical disadvantage and becomes the seat of a painful, chronic strain. As the hip becomes more and more stiff, flexion is progressively limited, and sitting is difficult and uncomfortable. With the continued progress of the disease the deformity increases, and stiffness in bad position results. In certain cases severe acute exacerbations occur which necessitate confinement to bed.

DIAGNOSIS

There should be no difficulty in recognizing osteo arthritis of the hip, from the type of individual, the history of trauma, the characteristic limitation of movement, and the typical radiological appearances.

PROGNOSIS

The disease is a progressive one and little can be done to stay its course. Without treatment, ankylosis usually results, often with extreme deformity, and the fixation of the joint is usually followed by relief of symptoms. The value of treatment is in placing the joint in a good functional position even though it be stiff.

TREATMENT

General Treatment has already been described

Local Treatment

If the case is seen in the early stages, when pain is the pronounced feature, rest and fixation are the first requirements, not only to alleviate the pain but to prevent progressive flexion and adduction of

the limb. Therefore while the disease is active and pain and muscular spasm are present, rest in bed with traction by weight and pulley and fixation are indicated.

When the acute stage has passed the patient may benefit greatly by simply using crutches and keeping the weight off the limb by a thickened sole on the shoe on the sound limb. Use within limits, short of irritating the joint, is valuable in maintaining function. If such exercise produces pain which is persistent and lasts for a period after the activity ceases, then it may be assumed that the joint is being used too freely and that additional protection is required. Gentle massage to the muscles is useful, combined with movements of abduction and extension short of causing pain or muscular spasm, carried out two or three times at each sitting. At the same time faradism and muscle training by non weight-bearing exercises should be encouraged. Later, to prevent undue trauma to the joint when walking is resumed, a caliper splint may be used.

When the affection is painful surgical measures may be indicated. If the condition is quiescent and there has not been great damage to the head of the bone great relief may be obtained by gentle manipulation of the joint under general anaesthesia. This is particularly so if the condition is an early one with slight changes in the X ray and the patient complains of inability to perform some particular movement and this limitation can be confirmed on examination. McMurray says that if the pain produced by the movement is of short duration the result of manipulation will be satisfactory, but if the pain disappears only after a considerable time the result will probably be disappointing. Under the anaesthetic it is possible to discover whether the adduction and flexion is due to muscular spasm or to actual shortening of the adductor muscles. In the latter event tenotomy of the adductor tendons is necessary, followed by fixation of the limb in abduction for two weeks and radiant heat, massage and active weight-bearing movements as soon as possible thereafter.

Operative measures on the joint should be undertaken only when severe pain and disability are present.

The choice of operation will depend to a great extent upon the type, the age, the general condition, and the build of the patient. Clinically, three common types of individuals present themselves for treatment.

1 The youthful patient with a unilateral affection. Often there is a history of early trouble in the hip region, and the radiological appearance suggests an old trauma to the epiphysis, probably of the nature of a 'slipped' epiphysis. The femoral head is large and mushroomed as in spondylitis ankylopoetica rather than in osteoarthritis and the femoral neck correspondingly stout and broad.

2 A type in which the spine and the hips undergo progressive ankylosis. Here the surgeon is usually called upon to treat a bilateral ankylosis of the hip joints.

3 The most common type, when the disease is again mono-articular, and the patient is an old man

It is important from the point of view of treatment, to recognize these clinical types. The first patient, for example, is in good general condition and well able to withstand operative intervention. The second group present a special and intricate problem in view of the bilateral ankylosis, they require special consideration. The third type the old man with unilateral hip disease must be dealt with on the assumption that he is not able to undergo long and elaborate operations and on this account many of the usual operative procedures are inadvisable.

The Operations

1 Drilling of Bone For cases with much pain Graber Duvernay has suggested drilling the bone in the neighbourhood of the hip joint with the idea of increasing the circulation within the bone.

The operation consists of boring minute channels through the bone to the centre of the head of the femur with the object of profoundly modifying the circulation and thus relieving pain and arresting the morbid changes responsible for it. The bore used has a diameter of 3 millimetres. From 8 to 12 tunnels are bored through the neck of the femur to different parts of its head the canalization of which provides for the development of healthy granulation tissue and the creation of bone in the rarefied zones. New bone formation is evident in about 4 to 6 months. Advanced age and debility are contra-indications for this operation, which is otherwise suitable for most patients because of its comparative safety and the high proportion of successes achieved.

2 Arthrodesis Arthrodesis of the hip may be attempted in a variety of ways but in chronic arthritis it is notoriously difficult to achieve a considerable percentage of cases terminating in mere fibrous ankylosis. Nevertheless the operation is extensively practised, and when good bony fusion results the patient is certainly left with a painless stable hip. The resulting disability of a fixed hip is not usually a source of complaint, doubtless because of the progressive stiffness and limitation of motion which had been occurring for several years before. The following methods may be employed.

(a) *Albee's Method* With the patient in the recumbent position, a vertical incision 5 inches long is made from immediately below and medial to the anterior superior spine, along the medial border of the sartorius. The deep fascia is divided, the sartorius is retracted laterally, and the deep structures penetrated by blunt dissection. The iliacus and the rectus femoris are retracted medially and the hip joint exposed. Osteophytes are usually present round the acetabular rim, and are generally removed. No attempt is made to disarticulate the hip, with the head of the femur *in situ*, the upper hemisphere is cut away, the plane of division being parallel to the long axis of the femoral neck. The upper part of the acetabulum is similarly flattened, so that,

when the limb is abducted the raw surfaces of the femur and the acetabulum are in apposition. It may be necessary to tenotomize the adductors in order to secure the necessary amount of abduction. The leg is then immobilized in a plaster of Paris case for two or three months.

(b) *Operation by Pin* As ankylosis is so liable to failure because of the difficulty in securing absolute fixation after removal of the cartilage Watson Jones encouraged by the success of the Smith Petersen nail in the treatment of a fractured neck of the femur now uses a long heavy nail in the fixation of the joint in osteo arthritis. He does a formal arthrodesis followed in 14 days by the insertion of a heavy type of Smith Petersen pin along the neck and head and into the solid bone above the acetabulum. The author does the operation at one stage through a straight vertical lateral incision. The incision exposes the lateral aspect of the hip joint and a square block of bone is removed half from the acetabulum and half from the contiguous head of the bone. The nail is now inserted under vision until it just enters the lower aspect of this gap. The pieces of bone are prepared by removal of cartilage and cut into "small pieces." These and any more required to fill the cavity taken from the ilium are placed into the gap in the hip joint and punched firmly home. The pin is now driven hard through the area where the chips are into the ilium. This ensures a firm arthrodesis.

The operation relieves the pain but yet allows a considerable degree of activity provided that the joints of the lumbar spine and the opposite hip are mobile.

3 Arthroplasty Arthroplasty in general is not attended with favourable results in chronic arthritis of the hip, and as it is associated with considerable shock it can be employed only in the case of young patients or in specially selected older cases. Although theoretically ideal the ultimate results are disappointing. Arthroplasty may be carried out by several methods.

(a) *Formal Arthroplasty* The joint is exposed through a Smith Petersen incision and the head disarticulated from the acetabulum. The osteophytes are removed and a third of the circumference of the head or the whole head removed. The acetabulum is carefully gouged out, and a well shaped cavity obtained. A flap of fascia lata is obtained from the lateral side of the thigh and folded double. One layer is wrapped round the head and neck of the femur where it is sutured in position. The second layer is laid into the acetabulum and carefully sutured to the surrounding soft parts. The head is then reinserted into the socket and the muscles carefully re-sutured at the completion of the operation. Traction is applied to the limb for a period of some weeks but movement is begun about the 4th or 6th day.

(b) *Smith Petersen Cap Arthroplasty* By his new operation Smith Petersen attempts to mobilize the joint by the insertion of a metal cap which remains permanently on the head of the femur. The joint

is exposed from the front. The margin of the acetabulum is removed sufficiently to enable the head of the bone to be gouged out of its socket. Bone is removed from both acetabulum and head so that they can be moved easily even after the vitallium steel cap is inserted. It maintains its position only by the shape of the bones so that the head may move in the cap and the cap can move in the acetabulum. It has been found that the opposite surfaces of the joint are covered eventually by a smooth lining of fibro cartilage or of hyaline cartilage. After the



FIG. 100.—Arthrodesis the nail method. Although a clinical success this nail is driven in in too medial a direction.

operation traction is applied to the limb and movement encouraged within a few days. In four weeks the patient is allowed to sit up.

(c) *Osteotomy of the Femoral Neck.* Girdlestone has described and shown cases where, in a bilateral ankylosis in a patient of poor physique, he has deliberately done a bilateral osteotomy of the femoral neck, producing an ununited fracture. The distal fragment is displaced upwards and movement with some degree of control results. It is obvious it will be done in a bilateral case in view of the shortening that results and probably only as a last resort, yet such an operation from its simplicity and certainty of movement if not of stability has its attractions.

4 *Cheilectomy.* The operation of cheilectomy consists of the removal of the osteophytes round the femoral head and acetabulum.

The joint is best reached by displacing the trochanter through a lateral U shaped incision. The osteophytes are as far as possible, chiselled off. Those at the upper aspect of the joint are easily dealt with, but considerable difficulty is usually experienced in dealing with those on the inferior aspect of the joint no matter what incision has been used. Fortunately the latter are rarely the cause of the disability. Cheilectomy usually results in a certain degree of increased joint movement and often also in a considerable relief of pain but occasionally it produces little benefit. Its result therefore, should not be guaranteed.

5 Acetabuloplasty This operation was devised by Smith Petersen at first for cases of protrusio acetabuli and later carried out



FIG. 201.—Cap Arthroplasty. This operation resulted in a movable hip over about 60° of flexion.

for osteo arthritis, old slipped epiphysis and old fracture of the acetabulum with intra pelvic displacement.

Through an anterior approach and with division of the direct head of the rectus femoris and wide retraction the anterior rim of the acetabulum is exposed. The osteotomy is carried out with a thin osteotome starting just below the attachment of the direct head of the rectus and carried mesially for one and a half inches then curving down to the cotyloid notch. When this fragment is free the capsule is incised on its antero superior aspect down to the neck and similarly on its inferior aspect. The fragment with its attached capsule may now be lifted out and joint head and neck of the femur exposed. The hip is now moved and it may be more of the acetabulum removed should the movement not be free enough. After closure of the wound a light traction is applied and in two weeks removed and the patient allowed up.

As regards results of this operation, although it has less to offer

than arthrodesis and although Smith Petersen himself has stated that it has not given the results hoped for Ghormley and Coventry believe that it still has a place in the treatment of certain painful hips particularly in aged patients who cannot stand the more drastic arthroplasty or the confinement in plaster necessary in arthrodesis

The author has used this operation with good results

6 The Bifurcation Operation of McMurray The great advantage of this operation is that it can be carried out rapidly and with very little shock The post operative recumbency too is neither so long nor so continuous as after an arthrodesis

TECHNIQUE A straight vertical incision of 6-8 inches is made on the lateral aspect of the thigh the upper end situated opposite the greater trochanter The incision is made down to bone and the shaft of the femur is exposed by dissection and elevation of the soft structures It is wise to be sure of the proper level for division by having a preliminary X ray taken with a measuring rod along the upper end of the femur The line of section should terminate immediately below the lower aspect of the acetabulum and should pass upwards and medially in the line of the femoral neck With the point of entrance assured it may be wise to take a further X ray to get the correct angle of bone division This division must be made with a sharp osteotome and care must be taken to ensure complete division If the division is incomplete and the fracture completed by manipulation there is a tendency for the bone on the medial aspect to splinter leaving a spur which interferes with subsequent manipulation

The lower fragment is now displaced medially and slightly upwards by means of a lever and by abduction of the leg so that its upper end comes to lie just below the lower border of the acetabulum In this situation the shaft of the femur lies outside the joint capsule and there is no fear of union occurring between the shaft and the acetabulum Great care should be taken to prevent a forward slip of the lower fragment—produced by the pull of the psoas McMurray points out two conditions necessary for success (1) The new site of the upper end of the shaft should be below the edge of the acetabulum (2) There must be union between the portions of the femur as otherwise a weak painful hip joint is the outcome In this way the original joint is short circuited as regards weight bearing and thus pain will be alleviated

A plaster of Paris case is now applied with the leg in the neutral position as regards abduction and adduction the plaster extending from the foot up to the nipple level but excluding the opposite leg After three months the case is removed and weight bearing may be resumed in a gradual way starting with the use of crutches A caliper is not usually used since it is often awkward to fit owing to the proximity of the shaft of the femur to the tuber ischium

The operation is simple of short duration and if performed correctly leads to relief of pain and to correction of shortening and other deformity with no loss of stability and does not cause strain on the lumbar region (McMurray)

Choice of Operation

Reverting now to the three clinical types which were referred to earlier, it will be seen that a variety of methods may be adopted, each advocated by some expert orthopaedic authority. Each case, therefore, must be considered on its individual merits, and all the circumstances reviewed.

In the case of the younger patients, where the femoral head is large and mushroomed and there is almost complete limitation of movement, and pain, the author usually performs an arthroplasty and gets better results with the cap method than by the formal arthroplasty.

Where both hips are ankylosed, a similar type of arthroplasty is strongly indicated. This should be carried out first on one side, and the result carefully watched for six months to a year before operation

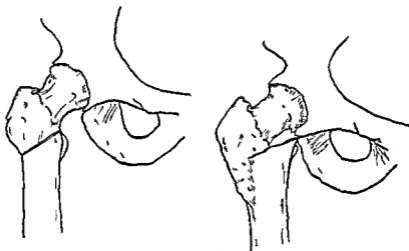


FIG. 202.—The Bifurcation Osteotomy.

is undertaken on the other side. At the end of that time it will be a matter for consideration whether or not operation is necessary in the second hip.

When the disease is confined to one hip joint, and the patient is old, the author recommends a pin arthrodesis and where that is not possible a bifurcation osteotomy in the manner described.

The Knee Joint.

The knee is more frequently the site of osteo arthritis than any other joint. The patient complains of stiffness, particularly after sitting, and of a feeling of tightness at the back of the knee, with discomfort and creaking on movement. There is often difficulty in mounting stairs. Exacerbations of acute pain occur. The joint is swollen, and there is persistent flexion deformity, or even subluxation. The general features are similar to those of osteo arthritis in other joints.

TREATMENT

Treatment should follow the lines laid down for the hip joint. When pain is severe, the joint should be protected from weight bearing by crutches, or by a Thomas's knee splint. Deformity should be corrected by traction, or by a wedged knee plaster, but undue fixation of the knee should be avoided, as it is apt to be followed by ankylosis. In severe cases, with complete destruction of the articular cartilage, ankylosis should be secured, according to the general condition of the patient, either by operation or by prolonged fixation.

Operation may also be called for when there is gross thickening,

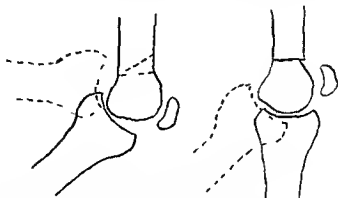


FIG. 203.—Wedge Osteotomy of the Femur in Rheumatoid Arthritis

Where a patient has a few degrees of movement in the middle of the arc of flexion it is possible by doing a wedge osteotomy of the femur as above shown to give him a knee joint which is much more useful. After the osteotomy he has full extension and has few degrees of movement in the fully extended position in the direction of flexion.

hypertrophy of the synovial membrane, loose body formation and damage to the articular cartilage. In such cases the operation of Magnuson already described is carried out.

When the joint is deformed, but retains a certain amount of free movement, the function may be substantially increased by correcting the position of the limb, usually by means of osteotomy. When there is marked flexion, for example, the removal of a wedge from the tibia or from the femur above the joint, will result in straightening of the limb without interfering with the movement already present in the joint.

Since Brooke in 1937 showed that the patella may be removed from the knee joint without seriously affecting the usefulness of the joint it naturally follows that its removal is the most reasonable treatment for various forms of arthritis of the knee. The type of case in which it is done with success is one where there is pain and tenderness in front of the joint around the patella, where there is much grating between the patella and its underlying bone, or where there has been a fracture which has united with irregularity of the bones on the articular surface. Any masses of hypertrophied synovial membrane are also

removed and in some cases the menisci as well. The operation is simple and is carried out through a straight vertical incision enucleating the bone from its attachments as closely as possible. The fascia is stitched firmly and after treatment of active functional movements begun in two to three days. The results are surprisingly good.

A formal arthroplasty of the knee in a post-traumatic arthritis is worth a trial in young patients. It is essentially conservative in nature and if unsuccessful does not prejudice the chances of a later arthrodesis.

TUBERCULOUS RHEUMATISM

The term *tuberculous rheumatism* has been applied to various cases of polyarthritis in which the etiology is thought to be tuberculous though the joint is not directly affected by the tubercle bacillus but by its toxin. The clinical picture of this condition was first described by Poncet of Lyons in 1897. Poncet treated a suppurating tuberculous hip joint in a young patient who also had pain and swelling of the wrist and interphalangeal joints. Later there was a flare up in the knees and feet which subsided in a few weeks but was followed by additional attacks of polyarthritis apparently of the atrophic type. Poncet's reasoning was that since there was no evidence of any other infection in the body and since the patient had definite tuberculosis of the hip the likelihood was that all the lesions in the joints were due to the same cause. He was so struck with the relationship between tuberculous disease and many cases of polyarthritis that he is quoted as having stated that in the presence of rheumatism that which one should demonstrate in the very first place is that it is not tuberculous.

Poncet described two forms of tuberculous rheumatism (1) the acute or subacute and (2) the chronic which included those cases which we would classify as rheumatoid arthritis and osteoarthritis and in which the joints usually present no specific evidence of tuberculosis. In such cases there is usually associated visceral tuberculosis a tuberculous family history or the presence of a true tuberculous joint in any patient before associated with or following a polyarthritis of any type.

Poncet's views which received wide acceptance in France have not been confirmed by experimental work or by the carefully checked clinical findings of workers in this country. There seems to be little doubt that a very small percentage of cases of arthritis of a rheumatoid type is of tuberculous origin. These cases occur in patients who have other tuberculous lesions usually of a quiescent character and they are in all probability due either to the action of the tubercle toxin on the joints or as has been suggested to the action of an attenuated type of tubercle bacillus. The pathological changes in the joints have in these rare cases been found to be modified tuberculous ones. The whole subject is somewhat confused but one can say that the con-

dition is far from common, and that it is not possible to distinguish clinically those cases which are of a tuberculous nature

INTRAPELVIC PROTRUSION OF THE ACETABULUM

Intrapelvic protrusion of the acetabulum was originally described by Otto in 1824, and is often known as the "Otto pelvis". Its main characteristic is a bulging of the acetabular floor towards the pelvic basin, so that the socket becomes extremely deep and the head of the femur is deeply embedded in it. Otto originally attributed the condition to gout but it is now generally assumed that the deformity is not a specific one but may occur in many and various lesions at the hip joint.

ETIOLOGY

Medial displacement of the acetabular floor may follow gross lesions at the hip. Thus fracture, neoplasms, tuberculosis and pyogenic arthritis may be the causal factor. While this must be borne in mind in investigating a hip which shows protrusion of the acetabulum, it is certain that such gross and usually obvious lesions play no part in the development of the true Otto pelvis.

Golding in a recent study suggests that there are two main types

1 Due to a growth disturbance of the acetabulum

2 Due to "rheumatic" infection

These can be distinguished on clinical and radiological grounds

(1) **Juvenile Osteo-asthenic Protrusion** Eppinger originally suggested that a disturbance in the growth of the Y shaped cartilage, leading to alteration and gradual displacement, would explain the error, and Golding suggests that this group can be separated from the others by the long absence of symptoms and by the complete absence of radiological change in the bones or the articular cartilages. The condition develops at the age of puberty in girls in the absence of signs of arthritic or traumatic changes in the hip joint, probably as a result of weakness of the bone tissue. To this group the name *arthrokatadysia* suggested by Verrall is applicable.

(2) **The Rheumatic (Infective) Group** This group is characterized by the early onset of symptoms and by definite radiological changes in the articular cartilage. It is probable, as Golding points out, that the type of infection is not specific. Thus it may be of the nature of a subacute streptococcal arthritis, or be due to gonococcal infection, in each case the incidence of the infective process must be more marked in the acetabulum than in the femoral head, and the virulence of the organism must not be such as to create extensive joint destruction. It has sometimes been suggested that all cases of intrapelvic protrusion of the acetabulum are due to osteo arthritis. There

is good reason to believe that this is wrong and that the radiological appearances of osteo arthritis are the sequelæ of repeated trauma and disordered function in an already damaged joint

CLINICAL FEATURES

In the first group there is limitation of movement at the hip joint from an early age. The movements most affected are those of abduction and adduction and the attention of the patient may be attracted to their limitation by inability to perform some simple act such as swimming or even crossing the limbs when sitting. Later pain appears and is coincident with the supervention of osteo arthritis the result of the mechanical disability of the joint.

In the second group pain and limitation of movement are noticed at the same time and progress. In addition to the loss of abduction and adduction there is often some limitation of flexion and a flexion deformity—the result not of the acetabular protrusion but of the associated arthritis—may appear. There is usually a pronounced limp.

Depending on the severity of the lesion there may be an accentuated lumbar lordosis. The great or the lesser trochanter may be made to grate against the side wall of the pelvis when attempts are made to abduct and adduct the limb while on abdominal palpation a globular swelling projecting into the pelvis may sometimes be felt above Poupert's ligament. The protrusion may be palpable on rectal or vaginal examination.

The Radiological Appearance. The acetabular deformity is readily recognizable on X-ray examination. In early cases of the non infective group the floor of the acetabulum is thin and wafer like and may protrude anything from a few millimetres to five centimetres into the pelvis. The head of the femur is sunk into the socket and the margins of the acetabulum appear to overhang the femoral neck. The articular surfaces are intact though there is often some loss of joint space.

In the infective group the deformity is complicated by the radiological evidence of infective arthritis. Thus the articular cartilages are often eroded and the bone tissue of the femoral head may be irregularly sclerotic and rarefied. In this group there is often a deposit of new bone on the pelvic surface of the acetabular floor which has the effect of acting as a splint to prevent complete perforation of the acetabulum.

A series of X-rays from a case of the present writer's is shown which demonstrates the course of the disease. In this case the condition was believed to be an example of Poncet's tuberculosis—an arthritis produced by the toxins of tubercle and therefore not essentially tuberculous.

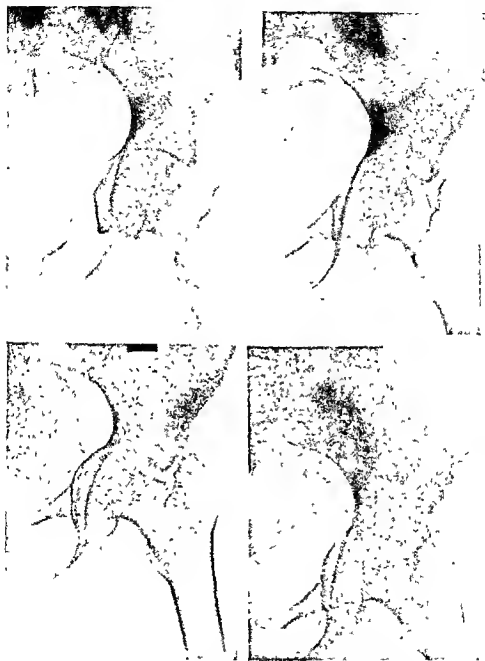


FIG. 204.—Intrapelvic Protrusion of the Acetabulum.

A case of the writer's, showing the gradual boring of the head into the acetabulum. The X-rays are taken at three-month intervals.

In the late cases there may be superadded the signs of osteoarthritis—eburnation of opposing surfaces and marginal osteophyte production.

THE NEUROPATHIC JOINT

(Charcot's Disease of Joints)

This condition which arises frequently in cases of *tuberculosis dorsalis* and occasionally in general paralysis of the insane was long regarded as *syphilitic in origin* but is now known to occur in such non specific conditions as *syringomyelia*, *paraplegia*, *myelitis* and peripheral nerve lesions. This has led to the exclusion of syphilis as an immediately causative influence.

The affection occurs in 4-10 per cent. of cases of *tuberculosis* and in about 25 per cent. of cases of *syringomyelia*. It is rare before the age of 40. Mentioned in order of decreasing frequency of involvement the joints most commonly affected are the knee, foot and ankle, hip, intervertebral joints, elbow, shoulder and wrist.

PATHOLOGY

King has written a very convincing monograph on the pathology and etiology of this condition.

The outstanding feature is the pronounced and rapid destruction of the articular surfaces. The compact bone underlying the cartilage is also destroyed until eventually the cancellous tissue is laid bare. The bone ends are therefore extremely irregular and owing to the great instability of the joint liable to become displaced.

The capsule is thickened and the intra articular ligaments destroyed. The joint cavity is enlarged due partly to the destruction of bone and partly to the recession of the capsule which gradually acquires more and more peripheral attachments as the articular margins are worn away. Neighbouring joints or bursæ may also become involved and lead to still further deformity. Eventually bones such as the talus may come to lie loose in the joint cavity.

The joint cavity is lined by a ragged looking synovial membrane bearing numerous villous processes and polypoid masses. This membrane may be continued over the bone ends. Its structure is fibro cartilaginous and the polypoid bodies are also formed of cartilage.

In certain cases there is a remarkable tendency for new bone to be deposited in the form of osteophytes or of plaques in the capsule. Occasionally a layer of new bone is deposited around the diaphysis for some distance beyond the articulating ends—a condition never met with in osteoarthritis. Not infrequently bone is also formed in the interfascial planes outside the capsule. To this form of the disease the term *hypertrophic* is applied when the excessive destruction of bone takes place without any attempt at new bone formation. The condition is described as *atrophic*. The atrophic type is said to be more common in France than in England and to affect particularly the joints of the upper extremity especially the shoulder and the wrist.

Brailsford has produced some suggestive evidence to show that the hypertrophic and atrophic types of the disease are really stages in the same process. He has followed a case by serial radiography, and his findings apparently show that in neuropathy there are three distinct stages

(i) A stage of *hydro arthrosis* with distension of the joint by serous effusion

(ii) A stage of *atrophy*—or better destruction



FIG. 20c.—Charcot's Disease of the Elbow Joint

(iii) A *hypertrophic stage* associated with new osseous deposits about the joint

These observations are of some interest in view of King's recent observations on the pathology of the neuropathic joint.

Charcot distinguished also between "benign and malignant" forms of tabetic arthropathy. In his benign cases the disease completely disappeared or did not proceed to complete disorganization of the joint. The malignant group included those in which the bone destruction was advanced, and where absolute disorganization and dislocation of the joint were invariable sequelæ.

Pathologists have not yet been able to assign with any degree of definiteness, the responsibility for maintaining the trophic nutrition of the joints to any one area of the spinal cord. Collier and Pitt have

demonstrated a partial atrophy of the right Clarke's column in the lower and mid dorsal region along with some changes in the motor cells of the anterior horn in a case of Charcot's disease of the left knee

King has given a complete account of the microscopic anatomy in a typical case. He found that while the histological picture varied in different parts of the joint the following features could be typically observed

(1) In some areas small fragments of dead bone were present some still attached to the articular surface others situated in the neighbouring connective tissue. The bone around the Haversian canals was necrotic in places the fibrous tissue was granular and the vessels degenerated

(2) There was marked cellular activity in many parts consisting of fibroblastic proliferation and excessive development of bone and cartilaginous tissue particularly in relation to pieces of necrotic bone. The bone and cartilage showed a great variety of appearances. In the areas of proliferation the vessels were well developed and the completely formed vessel walls suggested neoplastic rather than inflammatory vascular proliferation.

(3) There was no microscopic evidence of syphilis. Old trauma was suggested by the irregular distribution of large numbers of cells containing blood pigment indicative of hæmorrhage

(4) That the new growth of bone was associated with architectural remodelling was shown by the decalcification of certain areas. In some of these osteoclastic activity was evident but in others osteoclasts were completely absent and the mechanism of bone removal in them is apparently by halsteresis

ETIOLOGY

The importance of trauma in the production of this condition has been shown by the experimental work of Eloesser. After anaesthetizing a limb by section of the posterior nerve roots typical Charcot's joints were produced only after trauma to the anaesthetic joints. Axhausen and Nageotte have shown that the implantation of a small piece of live bone into such a part as the ear of the rabbit results in a curious reaction of the connective tissue metaplasia occurring with the formation of bone and cartilage. Leriche produced similar changes in joints by implanting pieces of fresh bone. This results in a remarkable proliferation of the surrounding tissues with thickening of the synovial membrane formation of polypoidal processes and osteo cartilaginous formation in the neighbouring tissues

These changes experimentally demonstrated by Leriche bear a close resemblance to the changes observed by King in neuropathic arthropathy. In both the mechanism of the process is evidently a reversion of the cells of the capsule—and of the bone—to a primitive

mesenchymal state a rapid proliferation of them and subsequent redifferentiation as cartilage bone and osseous tissue King suggests that in Charcot's joints the stimulus inaugurating this process is the presence in the joint of small portions of dying bone These are the result of multiple traumata only possible in anæsthetic joints

It is interesting to note that King finds a distinct resemblance in neuropathic arthritis to the changes occurring in osteo arthritis In the neuropathy the pathology is of course more grotesque but in both there is destruction of articular surfaces and marginal exfoliation after a period of cellular dedifferentiation towards a primitive mesodermal tissue

If as King suggests the stimulus to these changes should prove to be the products of dissolution of small segments of dying bone there is good reason for accepting Brailsford's dictum that the atrophic—i.e. destructive—phase of neuropathic arthritis is only a prelude to the later proliferative stage

The Clinical Course

The onset is often sudden and unexpected premonitory signs are rare The patient may find on going to bed that one of his joints usually the knee has become greatly swollen The swelling gradually increases and is eventually associated with a firm diffuse cedema of the leg and foot The swelling gradually subsides and the joint is then found to be unduly lax the bones can be freely moved one upon the other in abnormal directions and to an unusual extent

Later deformity arises as a result of the destruction of the bone ends of subluxation of a copious effusion into the enlarged cavity or of the formation of osteophytes Throughout the whole course there is a striking absence of pain The process may occupy only a few weeks or months and by the end of that time the joint is often flail and the patient completely crippled The disease then gradually diminishes in seriousness and may even be completely arrested so that the subject may live for years without any material change in



FIG. 206.—Charcot's Disease of the Knee Joint

the disabled joint. Other joints may in the meantime pass through a similar series of changes.

Not infrequently a diffuse erythematous blush may be found over a neuropathic joint particularly at the onset of the disease when the joint is swollen and oedematous.

Charcot's joints are more common in females. Though the absence of joint pain is noteworthy, the subject suffers the other evidences of tabes in the shape of lightning pains and sensory phenomena, the Wassermann reaction is usually positive.

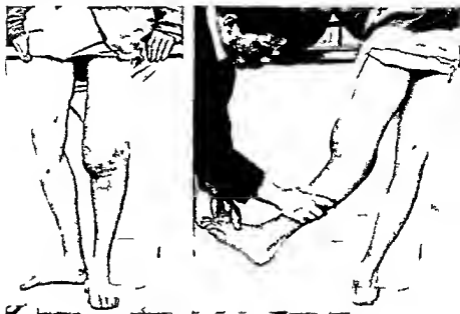


FIG. 207.—Charcot's Disease of the Knee Joint.
The painless and unnatural mobility is being demonstrated.

TREATMENT

Antisyphilitic treatment has no effect upon the progress of a Charcot joint which has already developed and cannot prevent the development of such a joint.

Locally immobilization in splints or a plaster of Paris case may be useful in stabilizing the limb.

In the case of vigorous patients with a life expectancy of several years the author recommends operation. For the spine a fusion as in tuberculosis is carried out for the hip intra articular and extra articular arthrodesis. In the knee resection with or without bone grafting or arthrodesis is the method of choice. Although this is not uniformly successful it is worth a trial. Soto Hall recommends a two stage operation. The first stage is a multiple drilling of the bone ends with a view to influencing their vascular condition—the chief

cause of failure of arthrodesis Six weeks later the ordinary arthrodesis is carried out

When the ankle joint is affected and especially when the disease is advanced amputation should be seriously considered The site of election is about $5\frac{1}{2}$ inches below the knee and the stump usually heals quickly and without suppuration

CHAPTER IX

AFFECTIONS OF THE EPIPHYSES

The epiphysis is the part of a bone concerned with growth in length, in addition, it takes part in the formation of joints and acts as an attachment for muscles and tendons. Parsons describes three types of epiphysis.

1 The pressure epiphysis, which transmits weight from one bone to another.

2 The traction epiphysis, situated at the point of attachment of muscles.

3 The atavistic epiphysis, which represents a part of the skeleton that has lost its function.

The epiphysis develops from a secondary centre of ossification and is at first separated from the main bone by an area of unossified cartilage. Later it joins the shaft to make the adult bone. The cartilage lying between the bony tissue of the epiphysis and the diaphysis is known as the epiphyseal cartilage, and it does not ossify nor does the epiphysis become joined to the body of the bone until growth has ceased.

Epiphyseal disturbances may be caused by many factors, of which the chief are circulatory changes, trauma, infection, diet, exercise, and endocrine disturbances.

OSTEOCHONDRITIS, OR EPIPHYSITIS

The term osteochondritis, or epiphysitis, is used to signify a non-inflammatory derangement of the normal process of bone growth which is wont to occur at the various ossification centres during the period of their greatest activity. No epiphysis in the body is immune to the disease and there is little doubt that the same underlying pathological process is present, no matter where it occurs, though the particular location modifies its features in certain respects. Cases have been recorded in which almost every epiphysis of the body has been simultaneously the site of this condition, though in each situation there have been essential differences due to the various stresses and strains to which the various epiphyses have been subjected.

ETIOLOGY

The etiology of epiphysitis is a most interesting study. Many theories have been put forward to account for it, but so far no clear cut

scientific proof of any one of them exists. The reason for this may be that since operation is not often indicated in this condition there have been few opportunities for a comprehensive study of the histology. The only general agreement which exists concerning the etiology of epiphysitis is that the disease is neither tuberculous rachitic nor syphilitic.

Many writers explain it on an infectious basis and this theory has initial evidence to support it in that operators who have taken the opportunity of investigating the condition have been able either to isolate an organism from the diseased tissue or to find definite evidence of an inflammatory process.

A Consideration of the Various Theories of Pathogenesis

1 Trauma It is generally agreed that in most cases a history of preceding injury can be obtained and some authors consider trauma to be the sole determining etiological factor. Legg describes the sequence of changes as follows:

As a result of injury there is an obliteration of a portion of the vascular supply of the epiphysis which consequently undergoes the atrophy of anemia. A compensatory hyperæmia of the adjacent portions of the diaphysis is the natural response and is the starting point of these hypertrophic changes which have been noted in the occurrence of broadening.

Elmslie has described a typical Perthes disease which developed in a hip joint which had been violently dislocated a year before.

Bentzon believes that these lesions of the epiphysis are caused by some disturbance of the arterial supply and that the formation of cartilage in the osseous tissue as well as the other pathological changes are due to an abnormal arterial hyperæmia. He found that the arteries supplying the various epiphyses were specially exposed to injury at points where pressure or trauma produced a bending of the epiphyseal cartilage. When the arteries are exposed to a moderately severe injury, it is not unlikely that the vaso motor nerves and the adventitia are so damaged that the nerves are paralysed and an active hyperæmia is produced in the epiphyseal region. He was able to induce pathological alterations in the hip in young rabbits by paralysing the vaso motor nerves to the upper epiphysis of the femur. The changes were similar to those found in Perthes disease and he concluded that the disease resulted from active hyperæmia produced by slight trauma to the epiphyseal arteries.

Bergmann believes that to explain this group of diseases an aseptic necrosis either alone or associated with other pathological conditions, must be assumed. Severe dislocations of the hip joint, and bloodless traumatic epiphyseal separations produced experimentally in rabbits failed to cause epiphyseal necrosis, but after partial section of the synovial membrane in which the nutrient vessels are carried, more or less extensive areas of necrosis developed in the epiphysis of the head.

These lesions were more intense when the ligamentum teres was also severed. Bergmann concludes that Perthes' disease is undoubtedly due to an aseptic necrosis though other factors congenital or exogenous may play a role. He thinks a purely traumatic explanation is improbable. Jackson Burrows puts forward the suggestion that although both conditions are due to interference with the blood supply the changes in aseptic necrosis may be caused by the interference with arterial flow while those of coxa plana may possibly be due to venous obstruction.

The supporters of the traumatic theory point to the history of injury to the greater frequency of the condition in boys to its more usual location either in weight-bearing joints such as the hip or in epiphyses which are subjected to a great strain as in the tubercle of the tibia. They also instance the case where Perthes' disease developed in a hip the site of a congenital dislocation which had been reduced the year before and point out that minor degrees of a similar change are a common radiological finding in old manipulated congenital hips.

The opponents of the theory point to the fact that it is frequently bilateral and that histological changes of trauma such as are seen in a recent fracture are usually absent. They also point to the fact that in many cases the temperature in the early stages is raised.

2 Constitutional Affections of Bone. Endocrinologists have pointed to the fact that in cretinism there is frequently some abnormality of epiphyseal development while a slipped epiphysis is frequently associated with infantilism. Lorwin in 1909 demonstrated the typical radiographic appearances of osteochondritis in a cretin of 11 years but this is an isolated observation.

Brand and Sundt have both relegated this disease to the group of bone dystrophies in which the endocrine balance of the body is disturbed and is presumed to be the fundamental underlying cause. This according to Platt is pure conjecture.

3 Infection. It has been noticed that the condition often occurs after a general septicæmia or following some previous infective state. In addition it is notable that the disease may simulate a mild infection. It may for example affect more than one epiphysis in the same person while there is usually a complete resolution as one sees in mild osteomyelitis. Writers on the subject have drawn attention to the frequency with which swelling and tenderness have been observed round the affected area. Kidner and Phemister found staphylococci in some cases and cases have been described which have followed a mild acute polyarthritis. Platt described two cases which passed through a stage of pyrexia for which no other cause could be found. Phemister had an opportunity to study histologically a portion of the epiphysis removed by curettage of the head of the femur. The tissue gave no microbial growth but otherwise it was said to be typical of an old infective lesion of bone probably of pyogenic origin. At operation there was evidence of an active synovitis but the articular surface of the deformed head retained its normal sheen.

Fraser recently described a case of Kohler's disease of the tarsal navicular which in its late stages was complicated by the formation of an abscess on the sole of the foot from which a staphylococcus was isolated. The patient made a complete recovery after the abscess had been opened and drained.

The writer believes that the usual sequence in cases of epiphysitis is that in the presence of a mild septicaemia attenuated organisms circulating in the blood may settle down in an epiphysis which has been subjected to mild trauma. The trauma may possibly be the stress and strain of weight-bearing or of muscular over activity. As a result of the settling of the infection in the epiphysis some necrosis occurs which results in the typical appearances of osteochondritis. The localized hyperaemia which follows the infection is usually sufficient to cure the disease and the joint recovers with little or no loss of function.

The points in favour of this conception are

- 1 The frequency of slight rises of temperature in the early stages
- 2 The ordinary signs of inflammation—heat swelling redness pain—which are often present over the affected part
- 3 The fact that in several cases a staphylococcus has been isolated from the diseased tissues
- 4 The definite evidence of infection obtained at operation
- 5 The signs of irritability of the joint as indicated by the muscular spasm
- 6 The fact that the disease may not be located entirely in the epiphysis but may involve all the joint elements
- 7 The fact that the disease affects the different epiphyses at different age periods also supports the infectious theory since the various epiphyses reach maturity at various times for while the young growing bone is particularly vulnerable to infection this liability decreases as the epiphysis matures

PATHOLOGY

The pathological changes in epiphyseal disorders are obscure because most of these conditions do not warrant operative interference and few of the cases end fatally. Our knowledge is therefore derived from a study of the radiological pathology and from the examination of tissues obtained experimentally though the latter often represents a late stage of the lesion. It is to Axhausen that we owe most of our knowledge. He pointed out that it was entirely a subchondral lesion and that there were roughly four stages in the pathology. There is first a disturbance of nutrition which is followed by a stage of necrosis. Later under some strain there is a pathological fracture and in the last stage of all the necrosed bone is replaced and we get the final condition of a more or less healed fracture.

This interpretation has been discounted by many writers as in some forms of osteochondritis there is a destruction of the epiphyseal cartilage and islands of cartilage are found in the already ossified areas.

As the condition advances, hæmorrhage and necrosis, and evidences of trauma become more and more marked

Undoubtedly these variations can be explained only by the various stages at which the superimposition of trauma occurs

SYMPTOMS

Clinically, there is a marked parallelism in the symptomatology of all the various osteochondritides. The onset is gradual, and there may or may not be a history of injury, commonly slight. As a rule the patient is in good general health, and is practically never acutely ill, although Platt has described cases where the patient was suffering from a mild septicæmia and frequently showed an irregular evening temperature.

The local effects of the disease are somewhat similar to those of early tuberculosis—slight pain, limp in a weight bearing joint, limitation of movement, and, at times, muscle spasm. The term "growing pains" is now held in disrepute, but it is highly probable that congestion of the rapidly growing epiphysis may indeed give rise to such symptoms so that the term may be re adopted with some justification.

All these symptoms are mild, indeed, many cases are symptomless, and are discovered only when deformities develop.

The affection may be bilateral, or only one side may be affected.

X-ray Appearance. The X ray appearance is very similar in the various forms of osteochondritis, and is usually out of all proportion to the mildness of the clinical picture.

They all show a broadening of the epiphyseal line. Areas of rarefaction and condensation are noted in the epiphyseal nucleus, and the outlines are indistinct giving the entire picture a hazy, mottled appearance. Following on this, the bony areas become "moth eaten" and the outlines correspondingly irregular. When the reparatory process begins, there is condensation and reformation of the lamellar structures, but the gross deformities remain, their type varying with the site of the disease and the treatment instituted.

OSTEOCHONDRITIS DEFORMANS COXÆ JUVENILIS

Osteochondritis of the hip is also known as Coxa Plana, Quiet Hip Disease, Flat Head, Perthes' Disease, Legg Calvé Perthes' Disease, or Pseudo Coxalgia. It was first described by Legg, of Baltimore.

It is a deforming condition of the femoral head, resulting from a disturbance of growth of the epiphyseal cartilage. Atrophy of the epiphysis occurs from absorption of the subchondral bony substance of the femoral head. The condition is essentially a disease of boys, and occurs usually between the ages of 5 and 10 years, but may be any time between 2 and 18. It is bilateral in about 10 per cent of cases. Sundt described 7 bilateral out of a total of 75 cases, while in a series of 243 hip joint lesions admitted to a special sanatorium, he discovered

41 examples of osteochondritis Gauvain found 12 cases out of 251 supposed tuberculous hips

SYMPTOMATOLOGY AND PHYSICAL SIGNS

Platt describes three stages in the symptomatology

1. The Stage of Onset The most constant early sign is a lump. The lump is usually, but not invariably, accompanied by pain, in fact, the absence of pain in many cases has been commented upon by various reporters. Although few observations have been made on the early stages of the disease, pyrexia has been noted by at least two observers Platt and Sundt. Muscular spasm is usually present in the early stages, so that the hip is completely fixed, as it is at the start of a true arthritis.

2 The Active Stage The stage of onset merges gradually into the stage of activity, without any clear dividing line. Platt states that the active stage may be said to extend from the time of the appearance of the first subjective or objective phenomena, to the time when the manifestations are so trivial as to give rise to the belief that recovery has taken place. The stage lasts from about six to eighteen months.

Lump The lump tends to disappear although it returns for short intervals and may occasionally continue indefinitely. It is a conspicuous feature during the existence of local pain and tenderness, or fixation of the affected joint.

Spasm The spasm noted during the stage of onset usually disappears quickly but leaves a residual limitation of mobility. The pain and tenderness have usually disappeared before the total abolition of the spasm, and the child may even be limping markedly with a completely fixed and painless hip. The usual position of the limb is one of slight flexion combined with adduction, in striking contrast to the abducted position of the early tuberculous hip. The attitude, therefore, forms a sign of considerable diagnostic importance in distinguishing between the two lesions.

Mobility of the Hip Joint During the active stage, the affected hip joint invariably shows limitation of abduction, medial rotation, and flexion. These movements are diminished, first because of the spasm of the adductor muscles, and, at a later stage, because of the true shortening of these muscles. Still later, the deformation of the femoral head provides actual mechanical conditions which prevent a full degree of movement. Perthes noted that abduction was limited even under anaesthesia.

The trochanter on the affected side is much more prominent than normally, and appears to project unduly in the lateral direction. If the trochanter is grasped from before backwards, between the thumb and the fingers, its antero-posterior diameter will be felt to be definitely thickened as compared with the normal side.

The *muscles* on the affected side are usually under developed but the atrophy is due more to lack of use than to any trophic disturbance such as is so common and constant a feature of the tuberculous hip joint. In spite of the considerable deformity of the head of the femur there is little if any shortening.

3 The Stage of Recovery The subjective and objective signs gradually diminish in intensity until finally a stage of apparent recovery is reached in which the function of the hip joint is restored so completely that there is little or no difference from the normal. Two signs however persist through life viz trochanteric thickening and limitation of the range of abduction.

X-ray Appearances

The X ray appearances are of a very special and interesting type and usually quite characteristic of the disease.

A Changes in the Femoral Head (i) *Flattening* The head at first is slightly reduced in its vertical diameter but with no appreciable increase in its lateral extent. Later there is a uniform opacity of the bony nucleus and thereafter signs of irregular calcification appear which denote the commencement of the next phase.

(ii) *Flattening plus Fragmentation* There is now apparently some breaking up of the bony nucleus of the epiphysis into a number of pieces. The pattern is not uniform and the size and number of these bony islands vary considerably. The condensation of lime salts in these fragments produces hyper calcification of the head as compared with the head on the other side. At the same time the head becomes still more flattened and as it expands it creeps out of the acetabulum in the direction of the great trochanter.

(iii) *Flattening with Fusion Changes in the Disorganised Nucleus* This marks the onset of the healing stage. The bony islands coalesce, and the density of the epiphysis diminishes until the shadow becomes not only uniform but comparable with that of the other side. The head however remains flattened.

(iv) *The Expanded Flattened Head* Even after the disease has healed a deformity of the head still remains and usually persists throughout life though possibly in rare cases where there has been no weight bearing on the joint the normal contour may be preserved.

B Changes in the Neck of the Femur The upper part of the neck is expanded and its metaphysal end becomes rounded off. At the same time the neck becomes progressively shorter but it does not usually bend.

Platt describes an alteration in calcification which produces an ill defined spongy zone in the upper part of the neck. This occurs at an early stage of the disease but in the second stage is replaced by a more regular pattern like arrangement consisting of areas of condensation.

C Changes in the Acetabulum Usually little if any change

can be detected in the acetabulum, but there can be little doubt that some alteration exists. Areas of condensation and zones of irregular line absorption may be seen but the appearance is usually ill-defined and difficult both to interpret and to describe.

DIAGNOSIS

It is not difficult to recognize a fully developed case especially if radiograms are available. In the early stages however there are certain points of similarity to early tuberculosis not yet involving the bone. The distinguishing points between the two are that pseudo coxalgia usually affects males of from 5 to 10 years of age, pain is



FIG. 203.—Osteochondritis of the Capital Epiphysis of the Femur. Bilateral disease.

an inconspicuous feature, extension and sometimes flexion, are fairly free, and the patient is usually a healthy child otherwise. A von Pirquet tuberculin test is usually negative but even a positive reaction does not entirely exclude pseudo coxalgia. Tuberculosis may affect either sex, at any age, though often the subject is young, all the movements of the hip joint are usually limited, the child is obviously unhealthy. Frequently other signs of tubercle are present and the von Pirquet test invariably yields a positive result.

PROGNOSIS

Pseudo coxalgia is a self-limiting disease with a strong tendency to spontaneous recovery. In a resumé of the end results Legg stated that in his experience relief from weight bearing in no way affected

the end results, i.e. in those cases in which weight bearing was not allowed, no better result was obtained than in those cases in which weight bearing on the affected leg was permitted throughout the course of the disease. He also showed that the final results could be placed in one of two categories, and that there were distinct differences between the two types of case.

1 The *mushroom type* does not show marked atrophy or fragmen-



FIG. 209.—An atypical form of Perthes' Disease where the condition has invaded the Neck of the Bone.

tation of the epiphyseal bone centres. In some cases the epiphysis migrates considerably towards the great trochanter, while in others this displacement is slight. Abduction, and, at times, rotation, is limited when the epiphyses show marked migration, otherwise motion at the hip may be restored to normal in adult life. In this type there is also less shortening.

2 The *fragmented type* shows marked variation in X-ray density in the epiphyseal centre and the neck, fragmentation of the epiphyseal bone centre and shortening and rounding off of the upper end of the

neck. Indeed the epiphyses in some cases seem to be obliterated. The ultimate limitation of movement and the permanent shortening of the leg are generally considerable in this variety.

Moller examined the end result in seventy four cases and found that 51.6 per cent had a permanent lump and were left with hip movements considerably restricted. In addition to actual disability there appears to be little doubt that the disease definitely predisposes to arthritis deformans at a later age.

Schmidt discusses the prognosis of Perthes' disease in twenty one



FIG. 10.—The effects of Perthes' disease. The condition has healed apparently with considerable deformity. The child walked with only a very slight limp.

undoubted cases of the affection. Seven showed no residual impairment of joint function but three of these had radiological evidences of coxa valga luxans and the mushroom shape of the head of the femur could be seen. Nine had some degree of lump and limitation of movement together with X-ray signs. The end results were satisfactory in the various cases in proportion as the early treatment had been systematic. Perfunctory treatment led to poor results. The inference is drawn that the prognosis of Perthes' disease although good on the whole is less certainly favourable than has been supposed and is definitely improved by early treatment by rest with traction followed by plaster support.

TREATMENT

It is generally agreed that no active measures seem to have been successful in modifying the pathological process. The aim of treatment

to day then is to protect and preserve the normal contour of the femoral head. The best method of doing this is by traction applied to the limb in order to diminish the inter articular pressure and in some cases this traction is continued until healing has occurred. In the acute stage he should be confined to bed, with traction applied to the abducted hip for some months. A plaster of Paris spica is then applied and later this is discarded in favour of a Thomas's walking caliper.

Sundt was able to watch over a long period, the effects of treatment or lack of treatment in the following three groups of cases.

- 1 Nineteen cases in which the hips were immobilized for two years
- 2 Sixteen cases in which the hips were immobilized for one year



FIG. 11.—Osteochondritis Deformans Coxæ Juvenilis. An early stage in the Right Hip Joint.

- 3 Twenty three cases which were allowed complete freedom throughout

He is quite definitely of the opinion that no difference in the degree of the deformity was found between the three groups.

It seems reasonable to presume however that the final deformity of the femoral head will tend to be less marked in the average treated case.

In spite of Sundt's findings and especially if the infective theory of the etiology is adopted it is a sound practice to immobilize the hip joint for a short period. In particular marked spasm, considerable limitation of abduction or some degree of pain are very definite indications for immobilization treatment. Any adduction deformity should be carefully corrected either by gentle stretching under an anæsthetic

or by the method described in the treatment of an early case of tuberculous arthritis



FIG. 212 Typical unilateral Ilerthea Disease

Operative Treatment

Operative treatment of any type is not warranted during the active stages and should be confined to stabilizing operations in the later stages when arthritis has developed

OSGOOD SCHLATTER DISEASE

In 1903 Osgood reported ten cases of epiphysitis of the upper end of the tibia in boys. Several months later Schlatter described a similar condition. At first it was thought to be simply a traumatic separation combined sometimes with an actual fracture of the epiphysis. This of course does sometimes occur but the true Osgood Schlatter disease shows in addition characteristic bony changes which stamp it as a definite disease entity.

The tibia is developed from four centres—one for the shaft, one for the lower, and two for the upper epiphysis. The tuberosity usually arises as a tongue-like protrusion from the lower end of the upper epiphysis but it may have two centres of ossification, one extending down from the epiphysis and one reaching up from the shaft. While the centre of ossification for the head appears first it unites with the

shaft last. There may be earlier points of union in the tuberosity which more easily permit circulation in the fragments.

Partial separation of the tuberosity from trauma such as violent contraction of the quadriceps muscle occurs mostly in males between the ages of 16 and 18. There is immediate pain over the affected site aggravated by any attempt to straighten the knee. The tuberosity is tender and swollen and radiograms show the detachment of the tongue like epiphysis.

True Osgood Schlatter disease occurs at an earlier age usually from 13 to 15. In most cases injury is to some extent an exciting factor but it does not play the prominent part that it does in the traumatic separation.

The onset of pain and local tenderness is insidious. The patient first complains of some aching in front of the knee after any exercise or after a long walk. In many cases such over exertion is the only history of trauma obtained. The pain is increased by full voluntary extension of the joint since the affected epiphysis is then pulled on by the contracted quadriceps muscle. There is also pain on passive complete flexion as the epiphysis is then dragged

FIG 913 Osteochondritis of the anterior part of the Upper Tibial Epiphysis—known also as Osgood Schlatter's disease

on by the stretched quadriceps. The epiphysis itself is tender and in many cases there is some localized oedema.

The radiographic appearance is characteristic. The texture of the bone nucleus of the epiphysis is altered. It is irregular in contour or even fragmented. There may be localized haziness in the adjacent tibial metaphysis.

Ollerenshaw reported thirty two cases the majority occurring in girls. Three cases were bilateral. He states that a fracture of the lower edge of the patella may accompany it.

DIAGNOSIS

Osgood Schlatter disease has to be differentiated from osteomyelitis sarcoma of the head of the tibia bone cysts and infra patellar bursitis.

The first three occasion little difficulty, but an infra patellar bursitis may be difficult to distinguish unless fluctuation is present. Aspiration of the bursal fluid usually indicates the source of the trouble.

TREATMENT

The condition is treated very much like an epiphyseal separation. First, a plaster case is applied, followed later by a Jones's knee cage with a stop joint to prevent undue flexion, last of all physiotherapy is employed. In contradistinction to the treatment of fractured patella, weight-bearing is permitted from the start but if there is great tenderness, rest in bed, or the use of crutches, may be insisted on. Flexion of the knee joint is not allowed for at least five weeks, and violent exercises are prohibited for about four months.

Complete restitution of the tuberosity to normal is usual. The condition, however, is apt to recur, and the cure is never really complete until the epiphysis joins up with the tibia.

OSTEOCHONDRITIS OF THE UPPER END OF THE TIBIA

Ritter reported the case of a girl, 7 years of age, who before the age of 4 years was extremely bow legged. By the age of 4, one leg had become normal in appearance, whereas the other remained extremely bowed. Radiographs showed a peculiar condition of the medial half of the upper tibial epiphysis, which, according to Ritter, was similar to the appearance in osteochondritis of the hip joint.

OSTEOCHONDRITIS OF THE LOWER END OF THE TIBIA AND FIBULA

In 1922, Sterne demonstrated a case of osteochondritis of the lower end of the tibia and fibula, while six years later Ritter reported a similar condition in the lower end of the tibia.

KOHLER'S DISEASE OF THE TARSAL NAVICULAR

Unfortunately, two quite different conditions have been named Kohler's disease, one affecting the navicular of the foot, and the other the head of the second metatarsal.

Kohler's disease of the navicular occurs usually in young children, especially between the ages of 3 and 6. It affects boys more commonly than girls.

The navicular is the last bone of the foot to ossify, and, as it forms the keystone of the long arch, it must be subjected to a very considerable strain while yet in the cartilaginous state.

The disease is distinctly analogous to the condition known as Kienbock's disease, which will be described later. It is probably an osteochondritis, but its cause has not been definitely established.

The clinical manifestations are often very slight, and consist of pain and swelling in the region of the tarsal navicular. The pain is exaggerated by weight-bearing, and the affected region is sensitive to movement and tender on pressure. There may, or may not, be reddish discoloration in addition to swelling. The patient limps, and usually walks and bears weight on the lateral border of the foot, to relieve the affected side.



FIG. 214.—Osteochondritis of the Tarsal Navicular—known also as Kohler's disease.

The condition is usually detected from the physical examination in conjunction with the history, and is confirmed by the radiograms which reveal definite changes in the bone. These changes consist of a narrowing of the bone in its antero-posterior diameter, along with a condensation of the bony structure so that, from the lateral view, the navicular may look like a sixpence seen on edge. There is no fragmentation of the bony nucleus. The joint spaces remain clear, and the neighbouring tarsal and metatarsal bones are normal in appearance.

TREATMENT

The treatment of this condition is comparatively simple, recovery usually occurring in a few months. A plaster case should be applied

to hold the foot in a slight varus position and weight bearing prevented by the use of crutches. After a few weeks the plaster is removed and adhesive strapping used to support the ankle and the mid tarsal region. The boot is fitted with a Thomas's heel i.e. with the medial half of the heel prolonged forwards towards the sole and sponge rubber pads inserted to relieve the strain on the longitudinal arch and especially on the navicular.

It is advisable to investigate any possible focus of infection especially the tonsils. If such a source is found it should be eliminated. Later flat foot exercises gentle massage and contrast baths are prescribed.

EPIPHYSITIS OF THE CALCANEUS

The posterior part of the calcaneus has a separate secondary centre of ossification which fits on the back of the main portion of the bone like a cap. It appears at the age of 8 and fuses with the parent bone about the age of 14. A pathological process affecting this epiphysis was first described by Sever and various writers in recent years have since drawn attention to it.



Fig. 915—Osteochondritis of the Epiphysis of the Calcaneus

There is frequently a history of antecedent injury, which is often slight in nature and may even consist of nothing more than running about on hard roads in soft shoes.

The onset is gradual and insidious. The first symptom is usually a limp which may, or may not, be accompanied by pain situated over the affected epiphysis. The pain is aggravated by wearing shoes with no heels, as this considerably increases the traction exerted on the epiphysis by the calf muscles. It is also increased by the pressure of the shoe, and, as swelling is usually present, the discomfort is considerable if the patient wears his usual size of shoe. Tenderness can usually be elicited over the insertion of the tendo calcaneus, and the patient shows a marked disinclination to make a full step as this entails dorsiflexion, and consequent stretching of the tendon.

X-ray Appearances. A lateral view, and an antero posterior one, with the foot in full dorsiflexion, should be taken. Marked irregularity of the epiphysis and diffuse thickening can be seen. The epiphyseal line is cloudy and partially obliterated, while the epiphysis itself is not uncommonly fragmented.

DIAGNOSIS

In the differential diagnosis the following conditions have to be considered: calcanean bursitis, tuberculous and pyogenic infection of the calcaneus, and teno synovitis of the tendo calcaneus.

PROGNOSIS

The duration of the acute condition is short, varying from a few weeks to a few months. Under appropriate treatment, the prognosis is excellent, but recurrences are possible until the parent bone and the epiphysis are solidly united.

TREATMENT

The objects of treatment are to relieve the strain on the tendo calcaneus and to prevent weight bearing on the calcaneus. In cases of unusual severity it is sometimes necessary to apply a plaster case to the affected leg from the toes to just above the knee, to hold the foot in a slight equinus position and relax the pull on the tendo-calcaneus. The plaster should remain on for about three weeks, and at the end of that time adhesive strapping should be applied round the epiphysis.

After the plaster is removed, physiotherapy, in particular massage, radiant heat, and diathermy, are beneficial in relieving the acute symptoms. A sponge rubber heel should be worn inside the shoe, and ordinary rubber heels fitted and used during the period of convalescence. Full weight bearing is allowed at the end of two months from the start of treatment.

Vertebral Epiphysitis or osteochondritis juvenalis dorsi has also been described. For a full discussion of this disease, the reader is referred to the section on deformities of the spine.

COXA VARA

In the adult femur the neck is set on the shaft at an angle which varies from 120 degrees to 140 degrees. A decrease in this normal neck shaft angle is known as coxa vara, while if the angle is over 140 degrees, coxa valga is said to be present.

Coxa vara consists, therefore, of a depression of the neck, and is a feature of many different conditions, although at one time it was thought to be due invariably to active softening and bending of the bone. The depression of the neck results in certain obvious mechanical disadvantages. The normal opposition between the joint surfaces is lost, since the head of the femur no longer accurately fits the acetabulum. The trochanter is displaced upwards and hence, during abduction, is liable to impinge on the side of the pelvis. The marked shortening of the limb leads to a waddling gait, not unlike that of a congenital dislocation of the hip. As coxa vara is a symptom of many diseases, it is usually classified according to the condition which causes it. The following classification is substantially that of Key.

A. Congenital Coxa Vara.

Coxa vara may be a primary congenital deformity, occurring alone, or in association with other congenital defects, especially defective growth of the femur. It may also be a secondary congenital error, when it is associated with some intra uterine affection of bone, such as achondroplasia.

Congenital coxa vara, also described sometimes as cervical or infantile coxa vara is characterized, according to Fairbank by the presence in a radiogram of a triangular piece of the neck adjacent to the head being separate from the rest of the bone. The condition is often bilateral and often symptoms are evident as soon as the child walks but they may be delayed for some years.

The patient is usually small in stature and limps, and, in bilateral cases, rather resembles a congenital dislocation. Often there is pain and stiffness. On examination the great trochanter is on a level higher than the normal with consequent shortening of the limb. Rotation and abduction are limited, while there may be a flexion contracture present.

A typical case shows interesting radiographic features which are tabulated as follows although all may not be present in one case.

(1) The angle of the neck is reduced to something below a right angle.



FIG. 216—Coxa Vara from old Perthes Disease.

(2) The neck varies in length but is short and may even be non-existent and may be fragmented through incomplete ossification. Often the neck shows a prolonged lower extremity which forms a down hanging lip.

(3) The head is unusually translucent situated low in the acetabulum and may be fluff, in outline.

(4) There is a fragment of bone triangular in shape occupying the lower part of the neck close to the head. This is bounded by two clear bands traversing the neck and forming an inverted V. The inner band is the epiphyseal line while the other is abnormal.

(5) There is some deformity of the acetabulum due to the mal-position of the head.

(6) In extreme cases the great trochanter curves inwards is beaked and may articulate with the humerus above the acetabulum.

Golding includes the uncromelia due to a short femur in this group since he says it is merely a variation of and in some cases the early stage of the same condition.

Treatment The only method that offers any real hope is according to Fairbank an osteotomy. In choosing the position afterwards the deformity is corrected to an extreme degree so that a coxa valga is produced. The bone division is carried out a considerable distance below the trochanters. It has to be remembered that the upper fragment is mobile and is able to flex. The osteotomy is done obliquely from above and outside downwards and inwards so providing a sharp end to the lower fragment to impact into the cancellous tissue of the upper.

B Acquired Coxa Vara

This group is classified on an anatomical basis according to whether the primary error is situated in the head of the femur the epiphysis the neck or the trochanteric region. The following table indicates the respective causes of each type.

(i) Capital Coxa Vara

(a) Perthes Disease

(b) Destructive Arthritis (pyogenic tuberculous Charcot etc.)

(ii) Epiphyseal Coxa Vara

(a) Idiopathic

(b) Traumatic

(iii) Cervical Coxa Vara

(a) Developmental or constitutional disease—(rickets osteitis deformans etc.)

(b) Destructive disease—(tuberculosis osteomyelitis etc.)

(c) Fracture with mal union

(iv) Trochanteric Coxa Vara

(a) Destructive disease as above

(b) Fracture with mal union

If such an anatomical classification is adopted in describing individual cases the term *coxa vara* should be preceded by an adjective indicating the site of maximum deformity and supplemented by a description of the etiological factor e.g. capital coxa vara due to Perthes disease or trochanteric coxa vara due to old fracture.

The majority of the above types of coxa vara are discussed in the chapters devoted to the underlying lesions. The epiphyseal type alone will be described here.



FIG. 17.—Bilateral Infantile or Cervical Coxa Vara. Boy, age 6 years.

Epiphyseal Coxa Vara

Incidence. The condition occurs more often in males in the proportion of about 5 to 7. It commonly occurs between the ages of 10 and 17 when the capital epiphysis of the femur is actively growing although in females it tends to begin at a rather earlier age than in males. It is not usual to find the condition bilateral.

SYMPTOMATOLOGY

Epiphyseal coxa vara may be idiopathic (non traumatic) or traumatic.

(a) **The Idiopathic Type.** There is seldom any history of preceding illness or constitutional disturbance. The onset is gradual and in

many cases the earliest symptom is that the patient gets easily tired after walking or standing. He may then complain of pain, which may be confined to the hip but usually radiates down to the lower thigh and knee. These symptoms are evanescent and disappear for a time



FIG. 18.—Congenital Coxa Vara. A late case. Note the inward curve of the great trochanter.

only to reappear with increased severity. In the early stages the pain is relieved by rest and the patient is not troubled at night.

The pain is accompanied by a lump and, as the error progresses the lump may be present even when the pain is absent. The affected leg gradually becomes shorter and smaller than its neighbour and tends to turn laterally while its movements are restricted.

(b) **The Traumatic Type** In this type the patient has usually had a fall or received a blow on the hip some time before. In many cases however the trauma is very trivial and not infrequently the history is elicited that the patient had some disturbance in the affected hip even before the injury. Following on the trauma there is usually a dull ache associated with a little disability in the hip although occasionally the pain is so severe that it prevents the patient from being able to walk.

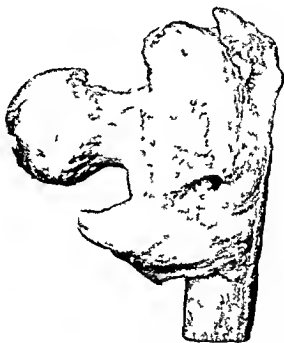


FIG. 219.—Coxa Vara following fracture of the base of the Neck and impinging the Trochanter

ETIOLOGY

1 Organic Disease Theory At one time adolescent rickets was considered to play a prominent part in the origin of epiphyseal coxa vara. Later this conception fell into disrepute although subsequent writers have from time to time revived the theory of late rickets.

Froehlich advanced the theory that the condition was due to a low grade staphylococcal osteitis and in two cases of coxa vara actually obtained cultures after boring into the trochanter.

Others believe it to be a constitutional disease while recent authors emphasizing the frequency with which it occurs amongst fat children suggest that it owes its origin to some endocrine disorder.

Kienbock believes that the cause of the trouble is an endocrine disturbance induced by disease of the hypophysis with consequent weakening of the skeletal system which is overburdened by the excessive body weight. As a result there occur in the region of the growth zone microscopic fractures and aseptic necroses which are of endogenic origin but affected by exogenic influences. Kienbock therefore suggests designating the condition as juvenile hypophyseal malacia of the neck of the femur.

2 The Static Theory It is assumed that there exists some disproportion between the body weight and the strength of the femoral neck as a result of which the neck becomes bent down. Whitman believes that in those adolescents who develop coxa vara there has been a mechanical predisposition in the shape of a slight depression of the neck due usually to early rickets. When this depression is present the part is subjected to increased strain, and eventually coxa vara arises.

3 The Traumatic Theory Many writers consider the condition to be a purely traumatic separation of a normal femoral epiphysis. The epiphyseal line is said to be the weakest part of the normal adolescent bone.

In some cases it is possible that the separation is due to a pathological condition in the femoral neck which results from repeated slight traumata and which paves the way for the final injury which causes the actual displacement.

There is no doubt that trauma and static influences are both important factors in the development of epiphyseal coxa vara but it is probable that they must act upon a femur in which the epiphysis is less firmly attached than normally. The pathological conditions which cause the loosening of the epiphysis are not definitely known but Key points out that they may be neither in the bone nor in the epiphyseal cartilage but in the periosteum of the femoral neck. In childhood this periosteum is thick and thrown into folds or ridges known as the retinacula of Westbrecht actually it is the chief factor in holding the head in place. In adolescence this periosteum begins to atrophy, and to approach the adult type thus tending to produce a point of weakness at the epiphyseal line. He also points out that most cases of coxa vara give a history of very rapid growth previous to the epiphyseal displacement and he thinks that during this period the periosteum crossing the epiphyseal line is stretched and thinned and consequently weakened thus permitting the epiphysis to be easily separated.

Fairbank describes a form to which he gives the name *infantile coxa vara*. He points out that the epiphysis is set obliquely on the neck and faces upwards and medially. This setting somewhat insecure as a means of supporting the body weight is strengthened by a spur projecting from the lower half of the metaphysis. Wahmsley has shown that this spur provides a natural ledge on which the epiphysis rests. Occasionally the spur ossifies from a separate secondary centre which

may remain isolated from the rest of the metaphysis by a strip of cartilage till puberty. This increase in the amount of cartilage weakens the neck in proportion to the body weight while the inadequacy of the spur increased occasionally by fragmentation of its centre allows the epiphysis to slide gradually downwards.

PHYSICAL SIGNS

During its early stages the condition is associated with considerable pain but by the time the patient is seen the disease is usually well developed and the painful acute stage is passed. He walks with a waddling gait the body swaying over to the affected side. The pelvis on the sound side tends to drop when weight is borne on the affected extremity.



FIG. 20—An Early Traumatic Case of Coxa Vara.

The separation has been slight and re-erect and because of the gap between the fragments manipulation and reduction may be a temporary.

The patient stands with the leg rotated laterally and slightly adducted while inspection shows the pelvis to be tilted down on the affected side. A slight scoliosis towards the affected side is present in the lumbar region and towards the sound side in the thoracic. The buttock is atrophied and the gluteal fold lower than on the normal side.

On palpation of the groin a hard mass can often be felt which moves with the femur—it is the thickened head and neck.

Measurement shows the trochanter to be higher than on the sound side the tip being usually situated about $\frac{1}{4}$ inch above Nelaton's line.

Movement on the affected side is limited. With the patient recumbent on his back the position of the leg is one of lateral rotation and slight adduction. Flexion is limited to about 80 degrees or 90 degrees.

and as the thigh is flexed it rotates laterally. Adduction and lateral rotation are free but abduction medial rotation and hyper extension are greatly restricted.

In a recent complete separation the signs resemble those of recent fracture of the neck of the femur and it may be possible to elicit a soft muffled crepitus.

X ray Appearance

The condition is progressive and the X ray appearance varies with the stage.



FIG. 221.—Coxa Vara

There is a fa h tic deformity on both sides.

(1) *The Pre slipping Stage* Brailsford describes the X ray appearance of the upper end of the femur in the pre slipping stage. There is some increase in the density of the metaphysial edge of the epiphysis and of the metaphysis in part or throughout its whole length with some woolliness of the outline of the extremity of the diaphysis. Those features should be sought for in children suffering from discomfort or pain in the hip joint. Their recognition demands measures to prevent slipping.

(2) *Early Stage* The head of the femur lies in the acetabulum but is rotated so that its lower and posterior borders are displaced downwards and laterally. The head is slightly displaced in relation to the neck its lower border projecting as a beak like process below the lower margin of the neck. The upper margin of the head is thinned out and separated by a short distance from the prominence made by

the upper angle of the metaphysis. The femoral neck bears its normal relation to the shaft, but its upper border is lengthened and roughly convex upwards, while its lower border is shortened and also appears to be more sharply curved upwards than normally. The lower border of the neck is buried in the concave cervical surface of the epiphysis, and appears to be shortened. In the angle between the lower border of the neck and the under hanging head, new bone is formed.

(3) *Advanced Type* The femoral head is atrophic, especially in its projecting lower half, and it has now become so rotated and displaced that only a small anterior portion is actually in the acetabulum. The articular surface is thus directed medially, backwards, and downwards. The projecting lower edge of the head is now curved laterally and upwards, and in contact with the lower border of the neck. The neck is thick and short, and its lower border sharply bowed upwards. The neck shaft angle appears to be decreased to about 90 degrees. The joint space is clear and there is usually no evidence of arthritis.

In cases where trauma has been severe, the head is often completely separated from the neck, and lies loose in the acetabulum. Except for this displacement, the contour of the bones is normal, but the joint margins and the joint space may be hazy from the extravasation of blood.

DIAGNOSIS

Diagnosis is suggested by the characteristic history, the age of the patient, and the adducted, laterally rotated position of the limb. In addition, the radiographic appearance is so characteristic that the condition should never be missed.

DIFFERENTIAL DIAGNOSIS

Coxa vara is to be distinguished from tuberculosis of the hip, osteochondritis, and congenital dislocation.

The *tuberculous hip* is adducted and medially rotated, with movement limited in all directions. The atrophy is greater, and the hip is more sensitive and painful even while at rest.

In *osteochondritis* the history, the limitation of movement, the slight atrophy, and the shortening are identical with those of a mild coxa vara. The chief points of difference are the age of the patient, and the X ray appearance. Osteochondritis rarely begins after the tenth year, while epiphyseal coxa vara seldom begins before it. In osteochondritis the head is not displaced but actually deformed, and may in the mushroomed type 'overflow' on to the upper border of the neck.

In *congenital dislocation of the hip*, there is a history of lameness from birth. In addition, the head of the femur may be palpated outside the acetabulum, and telescopic movement can be elicited in the majority of cases.

Brailsford believes that *renal rickets* may produce a disorganization of the metaphysis very like early cases of a slipping epiphysis. Renal rickets therefore should be excluded before any operative procedures are undertaken in these cases, the urine being examined for albumen on several occasions.

PROGNOSIS

In making a prognosis the fact must be considered that in a proportion of cases—about 1 in 60—the second hip becomes affected.

The end result depends to a certain extent upon the degree of displacement of the head but it may be modified by treatment.

A review of the end results from various sources forces the conclusion that save in the exceptional case, manipulation is apt to do more harm than good. This impression is reinforced by operative findings. The appearance of the usual type of slipped epiphysis at operation is such as to convince the surgeon that if manipulation had been attempted the strength required to reduce the displaced head would have done irreparable damage to the cartilaginous joint surfaces.

Most patients with a displaced epiphysis develop arthritic changes during adult life.

TREATMENT

The obvious treatment is to reduce the displaced epiphysis and to maintain alignment until it becomes fixed.

The methods employed are usually either prolonged traction in adduction or open reduction.

The treatment however depends to a great extent upon the length of time which has elapsed since the onset of symptoms. It is obviously futile to attempt to reduce by traction a separation which has been present for months.

For purposes of treatment epiphyseal coxa vara may be grouped into four common clinical types:

- 1 Early traumatic cases
- 2 Cases of some duration yet with an obvious line of demarcation between the neck and the separated epiphysis
- 3 Healed cases in young adults
- 4 Older cases with arthritis

1 The Early Traumatic Case In this type the head is normal in contour but has been displaced and there may even be a space between the neck and the upper margin of the head. The duration of symptoms is usually short.

Wardle has shown that the best method of treating early cases of slipped epiphysis is by means of traction in a position of adduction. There is much less trauma in this method than in any manipulative method and therefore the likelihood of getting a good movable hip joint is greatly increased. The patient is placed in a well made Jones's spinal frame constructed with extension ends to the leg pieces. No

provision is made for abduction of the lower limbs. Strapping extensions with tapes are applied to both legs from the groins to the malleoli and the groin straps fixed on the sole of the lesion. Both limbs are bandaged to the frame and on the affected side this bandage is used to correct gradually the lateral rotation which is generally

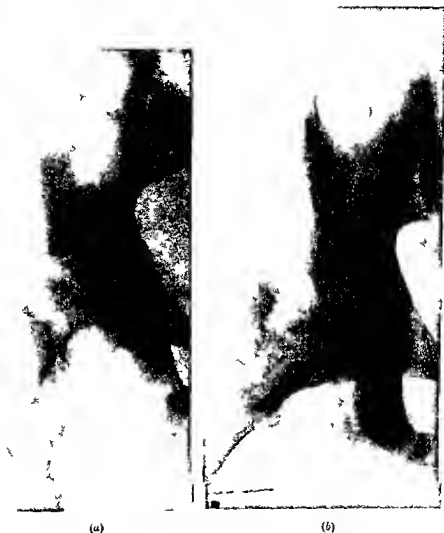


FIG. 22.—(a) Coxa Vara from a slipped Epiphysis of some months duration. Open reduction is the appropriate treatment. (b) After reduction.

found to be present. A steady and increasing traction is thereafter applied to the affected hip in an adducted position. The greatest care is taken of pressure points which are rubbed with spirit until dry and then powdered about every four hours day and night and the extension tapes tightened at the same time. Control X rays are taken every fourteen days until the epiphysis has slipped back into

place and traction is continued for a period of at least a month after this has occurred. Afterwards the frame is removed but the patient is kept recumbent and is allowed free active non weight bearing exercises at the hip joint. Later the patient is allowed up in a walking caliper splint which is worn for at least a year from the time treatment was commenced. Exercises in recumbency may be continued with advantage.

Key advises the use of cod liver oil and phosphorus during convalescence.

2 The Advanced Case of some months standing but with an obvious Line of Demarcation still present between the Head and Neck. This is the most common type of case. The head has slipped well down on the neck but although deformed and sickle shaped it is still recognizable as a separate mass of bone. Reduction by manipulation is impossible and open operation therefore must be resorted to. The hip joint is opened through a Smith Petersen incision and the head freed from the neck to which it is firmly fixed by a broad gouge. Even after it is freely separated it is somewhat difficult to get an accurate replacement owing to the free mobility of the capital fragment. This fragment may be temporarily fixed by towel clips which penetrate and grip but do no damage or by holding it in the acetabulum with a small gouge while the leg is abducted and medially rotated until the neck is manipulated into accurate apposition. When good apposition is got a guide pin is introduced up through the neck and followed by a Smith Petersen nail in the same way as a fractured neck of the femur is dealt with. No plaster is required and movements are begun at an early date.

Subsequent treatment should be on the same lines as in the early traumatic cases.



FIG 2 3—Slipped epiphysis treated by open reduction and retained by a Smith Petersen nail.

The patient danced in the chorus of a pantomime 18 months after

3 The Treatment of the Healed Case in Young Adults In this type the head is markedly deformed the neck is thickened and its upper surface rests against the upper portion of the acetabulum. No line of demarcation is present between the epiphysis and the neck and it will be difficult to decide how much bone to take off the neck. A plastic operation usually results in ankylosis while arthroplasty leaves a short leg.

It should be realized at the outset that even an approximately normal joint is unlikely to result and this being so the operation of choice is an osteotomy of the femur just below the trochanter. This is followed by fixation in a position of good abduction and medial rotation. This can usually be achieved without resort to tenotomy of the adductors.

4 The Treatment of Older Cases with Arthritis The treatment of this type is practically that of osteoarthritis and since operative treatment is a serious matter it should not be lightly undertaken. Where the patient is a poor operative risk, it is better to be content with palliative measures such as physiotherapy, rest and possibly a walking caliper. If these measures fail to give relief, operation may be unavoidable or even demanded. In such a case the simplest and quickest measure should be adopted and the operation attended with the slightest degree of shock is the abduction osteotomy of McMurray already described.

This gives a strong painless weight bearing limb whose function is extraordinarily good.

AVULSION OF THE LESSER TROCHANTER OF THE FEMUR

The lesser trochanter of the femur is the comparatively weak structure into which the ilio psoas tendon is inserted. Its ossification centre appears about the twelfth year and unites with the shaft at the eighth year so that during the intervening years it is liable to be avulsed by undue traction exerted by the ilio psoas.

The cause is usually traumatic and the condition therefore more often occurs in boys who are more subject to injury.

SYMPTOMS

One of the functions of the ilio psoas tendon is to flex the hip joint and therefore where the trochanter has been avulsed the patient is unable to perform this movement. In consequence a limp develops and at the same time attempts to carry out the movement are painful.

On examination tenderness is elicited in the region of the lesser trochanter and when the patient lies on his back on the examination couch, he is unable to raise his thigh. He is also unable to mount stairs unless he drags the affected limb after the sound one. He cannot bend from the hip and fails to pick up an object from the floor.

An X ray examination reveals the separation of the epiphysis
The prognosis is good

TREATMENT

Complete immobilization is unnecessary, it is usually sufficient to put the patient to bed in a sitting up position, i.e. the Fowler position. At the same time a means of preventing some abduction of the affected side should be adopted. The patient uses a back rest while sleeping. Union usually takes place in about six weeks.

OSTEOPOROSIS OF THE CARPAL BONES

This rare condition was first described by Kienbock in 1910, as an affection of the carpal lunate bone. Since that time a considerable volume of literature has accumulated, and many hypotheses have been advanced to explain its occurrence. It may affect many of the carpal bones in addition to the lunate—Buchmann, for example, states that it may also occur in the navicular, the multangulum majus, and the hamate. So many of Buchmann's cases gave a definite history of injury that he has named it traumatic osteoporosis of the carpus. When it affects the lunate however, the condition is usually called Kienbock's disease, and when the navicular is involved, Preiser's disease.

ETIOLOGY

There is usually a history of injury sustained while the hand is dorsiflexed but the trauma may be a very insignificant one, and in some cases no history of injury can be obtained.

Both Kienbock and Preiser believed the condition was secondary to an injury of the blood vessels, following rupture of the ligaments of the bone. Axhausen considered it to be a primary aseptic bone necrosis with a superimposed pathological fracture. Buchmann says that the explanation of the changes may lie in the theory of Leriche, i.e. that there can be no rarefaction without hyperæmia. He believes that all peripheral traumata are accompanied by a disturbance of the vasomotor equilibrium, which commences with constriction and ends with dilatation. This phenomenon he calls the traumatic axone reflex and he holds that when this is persistent, it gives rise to bone absorption.

Mutet and Gerard have grouped the affection into three types. In the first, fracture is primary. In the second type, the malacia is primary and pathological fractures take place in the diseased bone. In the third type, the malacia seems to be due to a latent osteomyelitis and the picture is that of an eburnated bone.

Although the condition is usually compared with the various osteochondritides previously described, it differs very materially from them. It affects, for example, only fully formed tissue, in which growth has been completed. It is perhaps, more correct to compare it with

Kummel's disease of the spine and with the absorption occasionally seen in certain fractures of the neck of the femur. These two conditions probably belong to the same group.

CLINICAL COURSE

The course of the disease can be divided into three stages:

1. An acute stage following the injury.
2. A period of freedom, sometimes lasting as long as two months.
3. A period of the actual disease, the symptoms of which may perhaps persist for years.

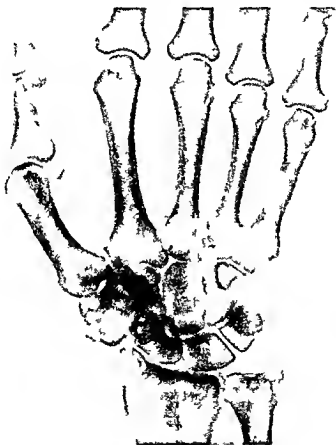


FIG. 4.—Osteoporosis of the Os Metacarpale III.

The acute stage follows the injury and lasts some weeks. The trauma is not uncommonly a mild one so that the patient is often not disabled. It may be a simple strain accompanied by swelling, pain and tenderness over the lunate, with limitation of the extremes of motion.

The painful period is followed by an interval of freedom from symptoms which may last months or even years. The period of active

disease then sets in. It is characterized by increasing disability by swelling and tenderness over the lunate. In the early stages the pain is aching, present only on extreme exertion and aggravated by excessive use of the wrist but it gradually becomes more persistent until in the final stages it is permanent and disabling.

When the condition is well advanced and destruction considerable, clenching of the hand fails to show the normal prominence of the head of the third metacarpal. This bone may even recede because of shortening in the vertical axis of the affected lunate. This sign is known as Finsterer's sign and is said to be pathognomonic of Kienbock's disease. Percussion over the head of the third metacarpal also



FIG. 25. Osteoporosis of the Carpal Bones, particularly affecting the Lunate Bone.

elicits tenderness and while pushing with the hand is painful, pulling actions are said to be accomplished without any discomfort. The depression normally situated just below the distal end of the radius is obliterated occasionally from the antero-posterior thickening of the lunate.

When the disease affects the navicular, the symptoms and signs are very similar. Pain is at first slight and felt only on exertion but it gradually becomes more and more severe and is finally present even when the hand is at rest. It may even become so excruciating that the patient is unable to sleep. Movement, especially dorsiflexion, is limited. There is usually slight swelling and tenderness over the navicular and the anatomical snuff box may be obliterated.

X-ray Appearance In early cases there are no characteristic X-ray appearances but later areas of rarefaction and of increased calcification may be seen. The affected bone is denser than the others and is also wider in its antero-posterior axis but thinned out in its short vertical axis. In the later stages the proximal aspect may become fragmented and areas may even disappear. Changes of an osteoarthritic character may also occur so that the articular surface of the radius may show osteoporosis and the points of insertion of the ligaments may become roughened.

It is a matter of doubt whether any line of fracture can be seen in the early stages. Some authors believe that it is present but invisible because of the superimposition of bone or because of the thickness of the bone. Kienbock however believes that it is not present at first but that it occurs secondarily and is pathological in nature. The first radiological evidence of the condition may be one or more small circular or oval areas of absorption or rarefaction in the centre of the bone. These soon fuse into a large area of decreased density and through this area the fracture occurs.

The histological findings in excised specimens vary with the extent and duration of the disease but in general there is absorption of the bone lamellæ with replacement by granulation tissue which goes on to form fibrous tissue instead of becoming calcified. This is a slow process and the deformity may be aggravated by fresh injuries.

PROGNOSIS

The prognosis depends upon the treatment. Poor results follow unrecognized fractures of the lunate bone just as they follow unrecognized fractures of the carpal navicular.

Under conservative measures many cases recover completely both clinically and radiographically. It is usual however to find evidences of osteoarthritis with severe disability some time after the condition has cleared up. Other cases have periods of either complete or comparative relief from symptoms while others again become continuously incapacitated.

TREATMENT

Treatment may be either conservative or operative and good results have been reported from both.

Conservative treatment should be tried first the wrist being put up in a plaster of Paris cock up splint as for a fractured navicular for two to three months.

If after that period the condition persists in spite of these measures a nice decision has to be made. It is tempting to remove the abnormal bone but the truth is that this rarely cures the pain since arthritis has started and will progress in spite of the removal of its cause. The best treatment is undoubtedly an arthrodesis of the wrist done after the manner of Brittain. The symptoms disappear after a successful arthrodesis and the loss of flexion is no disability.

CHAPTER X

PARALYSIS

Although the types of paralysis described in the beginning of this chapter may be of little surgical significance they are of considerable importance from the point of view of diagnosis

THE MUSCULAR DYSTROPHIES THE MYOPATHIES

Although the various muscular dystrophies present obvious differences they have nevertheless a number of common clinical features. They are often hereditary and though their manifestations are often present at birth they may be delayed until puberty or even later. The essential process in all is a simple muscular atrophy. The pseudo hypertrophic varieties are produced merely by the deposit of fat in the affected muscles. The newer studies on the vegetative nervous control of muscle metabolism indicate that the dystrophies are affiliated to the disorders of the vegetative nervous system in which creatinine, glycine and amino acid metabolism are deranged.

The chief clinical types of myopathy which will be described are

- 1 The pseudo hypertrophic type (Duchenne)
- 2 The juvenile type (Erb)
- 3 The facio scapulo humeral type (Landouzy and Dejerine)
- 4 The distal type (Gowers)
- 5 Amyotonia congenita
- 6 Myotonia atrophica congenita (Oppenheim)

1 Pseudo hypertrophic Muscular Paralysis (Duchenne Type)

This is a disease of early childhood. Frequently its first symptoms are observed when the child attempts to walk but sometimes the onset is delayed until the fourth or fifth year or occasionally until after puberty. In the late cases previous enlargement of muscles may have escaped notice. Boys are attacked much more frequently than girls in the proportion of five to one. In females the disease develops at a later age and is less severe. Sometimes several members of a family are affected and although the females usually escape they may transmit the disease to their sons.

SYMPTOMS

Usually the first symptom to attract attention is insecurity in standing or in walking, the child falls easily, gets up clumsily, and in going upstairs has to support himself by the banisters.

Enlargement of the muscles is most conspicuous in the calves, which often feel firmer than usual. The infraspinatus often shows enlargement, and is firm as well as bulky and prominent. The biceps is commonly wasted. The muscles of the forearm and hand are rarely involved.

One of the most constant features of the disease is a bilateral atrophy or even an entire absence of the latissimus dorsi and of the lower part of the pectoralis major. In consequence of this the axillary folds are thin or practically absent, and it is almost impossible with the hands in the arm pits to lift the patient up, for the shoulders offer no downward resistance.

The degree and the distribution of muscular weakness give rise to characteristic defects in the attitude and movements of the body. In standing the child preserves its balance by keeping the feet wide apart and throwing back the shoulders and upper part of the body. In walking the feet, widely separated, are lifted off the ground with difficulty, and the body is inclined first to one side and then the other. This waddling gait is effected by alternate contractions of the gluteus medius, these are necessary to enable the advancing foot to clear the ground. Occasionally, when the flexors of the hip are not weak, there is a "high stepping" gait, and in rising from the supine position on the floor the patient employs the classical method of "climbing" up his legs.

As time goes on certain deformities develop. The elbows and knees become flexed and the spine shows lateral curvature. Alternatively the patient becomes bedridden and is helpless, except perhaps as regards the movements of his hands. The limbs now become thin and the muscles—even those of the calf which were formerly enlarged—small and wasted. The electrical irritability of the muscles, normal at first, shows a quantitative decrease to both faradic and galvanic current when the disease is fully developed. The knee jerks gradually disappear as the weakness of the extensors of the knees increases.

Sensation is unaffected, weakness of the sphincters is rare, and the general health is not necessarily interfered with until the final stage of the disease. The mental condition is generally normal.

The disease progresses slowly and insidiously, but it is rare for a patient to reach adult life.

ETIOLOGY

The cause of the disease is unknown. Tinne believes it is associated with pineal deficiency, and states that four of his patients showed a pineal shadow on X ray examination, indicating premature calcification of the glands.

The disease is sometimes associated with hypoglycæmia, and it has lately been shown that the creatinine metabolism is disturbed

TREATMENT

Scientifically planned exercises retard the muscular lesion. Massage and friction may be employed to supplement these, but are of minor importance compared with the exercises. Tinne treated his cases by pineal substance, 1/10th of a grain three times a day for three weeks out of five, then thyroid and pituitary, and, as the patient grows older, testicular extract. Lewin, in view of the hypoglycæmia, gives suprarenal extract, 3/200 of a grain by the mouth three times a day.

In view of the abnormality in the creatin metabolism, glycine has recently been given with very marked clinical improvement.

2 The Juvenile Type of Erb

In this type the sexes are more equally affected than in pseudo-hypertrophic paralysis. It usually begins in the second decade of life, and the muscles of the upper arm and thigh, together with certain muscles of the shoulder and pelvic girdles are affected, those of the forearm and leg are generally spared. There is, therefore, a striking contrast between the size of the arm and forearm, and of the thigh and leg, in a typical case.

The biceps, triceps and supinator longus are the first muscles to show any change. Subsequently the latissimus dorsi, the lower part of the pectoralis major, the trapezius, the serratus magnus and the rhomboids are involved. The deltoid and the spinati usually escape. The atrophy of the serrati leads to bilateral winging of the scapulae. Later in the disease the glutei, the flexors of the hip and the muscles of the thigh, especially the quadriceps extensor, become wasted and weak. The gait and the manner of rising from the ground may be the same as in the pseudo hypertrophic form.

3. The Facio-Scapulo-Humeral Type of Landouzy and Dejerine

This is a type in which weakness of the facial muscles begins to develop in infancy, or is present at birth, and is followed by wasting of the scapulo humeral muscles. In other respects the distribution of the atrophy resembles that of the juvenile form, and the two diseases are in all probability of the same nature.

The hereditary nature of this type is sometimes shown by its presence in successive generations. In many cases, however, no other members of the family have been affected.

The characteristic feature is the early and marked involvement of the facial muscles. The orbicularis oris and orbicularis palpebrarum are prominently affected, the patient being unable to close the eyes completely, or to whistle or blow. A sphinx like face develops, the lips are everted, the lower lip projects and the mouth has, not inaptly,

been compared to that of a tapir. The smile is often peculiar for the mouth forms a straight line and the angles of the mouth are not drawn upwards and outwards.

After the facial atrophy develops the muscles of the shoulders and the arms are implicated and subsequently the muscles of the back, hip and thigh.

4 The Distal Type

The characteristic feature of this type is atrophy of the distal muscles of the limbs especially the extensors of the wrists and fingers and of the toes and ankles. The proximal muscles are not affected though occasionally the face is. The condition may be noticed in infancy or not till adult life.

Clinically the disease closely resembles the peroneal type of muscular atrophy. In the latter however sensory changes in the legs are often present and the facial muscles are never affected.

5 Amyotonia Congenita

This is a rare infantile malady characterized by smallness and extreme flaccidity of the voluntary muscles by loss of the deep reflexes and by a tendency to gradual improvement.

The condition is usually congenital and is noticed at birth or shortly afterwards. In a few cases it has developed in a previously healthy infant apparently as a result of diarrhoea or acute bronchitis. There is no evidence of either hereditary or familial tendency so that it is not certain whether this disorder should be included among the myopathies or not. The health of the parents including that of the mother during pregnancy has usually been good.

The limbs especially the lower ones are the most severely affected. The trunk is often involved the face but rarely. There is general weakness of the limb but no actual paralysis voluntary power in individual muscles although feeble being retained. The distribution of the muscular flaccidity is symmetrical. The limbs are flail like at all their joints and may assume the most curious positions. Thus *the wrist and the ankle may be so over extended that the metacarpus touches the forearm and the dorsum of the foot the front of the tibia*. The hands and feet are often long.

The children never learn to walk but adopt some strange method of getting about by rolling over and over or by assuming a squatting attitude so that the name *frog child* may be given to them.

Contractures are apt to occur in the course of time, and the knee and hip may be flexed.

The muscles show a lowered excitability to faradism—indeed when the amyotonia is severe the current must be very powerful to obtain any response. The strong current is borne without complaint despite the fact that no loss of sensibility to any other form of stimulation can be detected.

The superficial reflexes are normal, the deep are lost, but may return in cases in which improvement takes place. The sphincters are never affected. The mental condition is normal and the child learns to talk at the ordinary age. The growth of the bones and the general bodily development are not interfered with.

The course of the disease is one of slow and progressive improvement which may be hastened by the persevering use of massage and passive movements, although complete recovery has never been recorded.

6 Myotonia Atrophica

This is a very rare condition characterized by the association of muscular atrophy with a slow relaxation of the muscles of the extremities after voluntary contraction. This myotonic condition is very limited in its distribution. It is most conspicuous in the flexor muscles of the hands so that the patient finds it impossible to relax his grasp suddenly.

The atrophic weakness affects the facial muscles, the sterno mastoids, the vasti, and the dorsiflexors of the ankle, and occasionally the forearm muscles, the masseters and the temporals.

The disease is a familial one and affects the males rather than the females. Its manifestations usually appear between the ages of twenty and thirty. Its course is slow and progressive, and in many cases muscular wasting is present for several years before the myotonic state appears.

Diagnosis of the Myopathies

Well marked types are easy to recognize, but there are many aberrant forms in which it may be difficult to decide whether the muscular atrophy depends on an abnormal condition of muscular tissue or on disease of the spinal cord. In favour of a myopathy would be

- 1 The onset of the atrophy at an early age
- 2 Its occurrence in more than one member of the family
- 3 Its distribution. Progressive wasting of the muscles does not correspond to destruction of a definite group of cells in the spinal cord
- 4 The absence of fibrillary twitchings and of a definite reaction of degeneration
- 5 The condition of the tendon reflexes, which are never exaggerated and disappear as the muscular wasting progresses

FRIEDREICH'S ATAXIA

This is a developmental disease in which there is an ataxic paraplegia as a result of sclerosis of the postero lateral columns of the spinal cord. The symptoms usually appear during adolescence, and consist of inco-ordination and weakness of the legs, clumsy speech, nystagmus, scoliosis and pes cavus. The deep reflexes are absent but the plantar reflex is of the extensor type. In the later stages there is a profound loss of joint sense in the lower limb, and often diminished

tactile sense, although sensibility to pain and temperature remain unimpaired to the end

The characteristic claw foot deformity of the well marked case occasionally develops at an early stage even before the characteristic ataxia. For this reason a neurological examination should be made in cases of adolescent claw foot before operative correction is undertaken.

The disease is progressive and little can be done to arrest it.

PROGRESSIVE MUSCULAR ATROPHY

The progressive atrophic paralysis which characterizes this disease depends on a gradual destruction of the ganglionic cells in the anterior horn of the spinal cord as a result of chronic inflammatory or degenerative changes.

SYMPTOMS

Usually the initial feature is weakness or wasting of some of the small muscles of the hand especially those of the thenar eminence and the interossei. The atrophy gradually increases in extent until paralysis supervenes. A characteristic deformity is soon produced by the weakness of the interossei for the flexor muscles of the fingers flex the interphalangeal whilst the long extensor muscle hyper extends the metacarpophalangeal joints hence the claw hand or *main en griffe* appearance results. Weakness and wasting now spread to the arms, one limb being affected in advance of the other. In the forearm the flexors are first affected and in consequence the claw shaped appearance of the hand may now disappear. At a later period the deltoid the upper part of the pectoralis major, the biceps the brachialis and other muscles become atrophied, then the arms thin, emaciated and weak, hang like flails by the sides of the body.

Complete reaction of degeneration is rarely seen. The disease is progressive and the prognosis is bad. Should the sclerosis extend into the pyramidal tract, spasticity of the lower limbs, with exaggerated knee jerks and a positive Babinski sign, are added to the clinical picture. This last type is known as amyotrophic lateral sclerosis.

PERONEAL MUSCULAR ATROPHY

This is a slowly progressive form of muscular atrophy which presents a clinical affinity with the distal (Gowers) type of myopathy, and a pathological resemblance both to multiple neuritis and anterior poliomyelitis. As a rule the disease begins in childhood and is seen only rarely after the age of twenty five. One or more members of a family may suffer from it.

The first symptom to attract attention is weakness and wasting of the peroneal muscles, the feet become plantar flexed and inverted, so that the child walks on their outer borders. About the same time or perhaps earlier, the small muscles of the feet begin to atrophy, subsequently the wasting spreads to the muscles of the front of the

leg and later to those of the calf. The next muscles to be affected are those of the lower part of the thigh, especially the vastus internus, in consequence of the diminution in the circumference above the knee, the thigh is sometimes said to be bottle shaped, the neck of the bottle being the lowermost part. The patient is able to walk, for some time at any rate, the gait is high stepping.

After a period, the small muscles of the hand are gradually involved.

There is diminished irritability, or a complete loss of response to faradism, at an early stage of the disease. The ankle jerk is lost, frequently in the initial stage, but the knee jerk is preserved unless the extensor muscle of the thigh has become involved.

Pains and cramps in the legs are often complained of. In some cases the cutaneous sensibility remains normal, but as a rule patches of anaesthesia are present on the outer aspect of the legs and over the feet. The muscles are not tender. The power of the sphincters is preserved.

The disease is not fatal. It runs a very chronic course, and sometimes its progress is arrested.

ANTERIOR POLIOMYELITIS

This disease was unrecognized until the researches of Von Heine in 1840. Since that date it has been widely recognized and fully described. It is an acute infectious disease, occurring in both sporadic and epidemic forms. It is caused by the invasion of the central nervous system by a minute filterable micro organism the relationship of which to the disease has been abundantly proved by inoculation tests in monkeys. With increasing knowledge of pathology and incidence, the original name of infantile paralysis became inadequate. The disease first appeared in epidemic form in 1855 in Scandinavia, since which time outbreaks have occurred periodically, culminating in the appalling epidemic which swept the United States in 1916 when there were 13 000 cases in New York State alone with a mortality in New York City of 27.3 per cent. In the Danish epidemic of 1934 there were 4,500 cases out of a population of four millions, and of these *one third were over 15 years of age. It has been observed that older persons are more frequently affected in rural than in urban areas, and that the disease tends to be more severe in these areas.*

The disease has a seasonal incidence, being more prevalent in the warmer months of the year—July to October in the Northern hemisphere, and March and April in the Southern. Individual susceptibility varies greatly, it is not uncommon for a child who has shared a bed with a patient suffering from the disease to escape. Susceptibility is present in only about 2 per cent of children under 13 years of age and is greatest in the second year of life, owing, it is said, to the great vascularity of the spinal areas at this period. One attack is said to confer immunity.

Mode of Transmission It is generally accepted that the virus myelitis is carried by droplets from the nasopharynx of carriers recently been isolated from the stools of a convalescent case in the water supply of a house in which a case occurred the day (Sweden) It has also been suggested that a small group of in Essex occurring simultaneously might have been infected by the consumption of earth contaminated strawberries Human beings play a part therefore in dissemination, while dust, foodstuffs, domestic animals and poultry have been blamed

ETIOLOGY

The virus belongs to the filterable class, as it passes through a silt filter and asbestos It withstands exposure to light, heat, drying and freezing for a long time The weak chemicals used in throat gargles have no effect on it In man, the virus is most infectious during the first two weeks of the disease, after which it becomes inactivated Its habitat is in the central nervous system and the mucous membrane of the nose, throat, and intestine of the patient, never in the circulating blood It enters the nose and throat, multiplies there, and enters the central nervous system by the lymphatics connecting the upper air passages to the skull and spinal

Flexner and Noguchi, in 1913, isolated from the spinal cord of monkeys and human beings suffering from the disease, organisms of apparently peculiar to this disease which they called "globoid bodies" These have been obtained in pure cultures, inoculation into monkeys has reproduced the disease, and the organism has been recovered from the infected animals Koch's requirements therefore, have been fulfilled Serum from these convalescent monkeys has conferred immunity

Rosenow claims that certain strains of streptococci are the causative organisms These are stated to be polymorphous with a tendency to become very small In its minute stage the streptococcus resembles globoid bodies of Flexner and Noguchi Rosenow, therefore, concluded that the globoid bodies were the forms assumed by these polymorphous streptococci under anaerobic conditions

Further investigation is needed, in the meantime opinion favours the view that the globoid body is the likely etiological factor

PATHOLOGY

The illness is a general infection, the results of which are most marked in the central nervous system According to the modern conception of the disease, two processes are recognized as important—first, hæmorrhage and œdema, second, the destruction of the nerve cells of the anterior horn The paralysis is the result of the damage to the cells, but it is uncertain whether this is due to the direct action of the virus and its toxins, or is secondary to hæmorrhage in the inter-

stitial tissues. Probably it is a secondary effect the result of disturbances in the nutrition of the nerve cells the accumulation of waste products and the pressure of the œdema and the hæmorrhage.

The first stage is an acute interstitial meningitis resulting in an infiltration of small mononuclear cells probably lymphocytes in the vicinity of the blood vessels of the leptomeninges. The extent of this infiltration is proportionate to the vascularity of the area and is more pronounced in the floor of the fourth ventricle in the cervical and lumbar regions and particularly in the anterior fissure where the large vessels enter the cord.

As the pathological process advances the perivascular infiltration extending along the vessels enters the cord. Thus in the cord there is hyperæmia and a collection of small round cells in the lymph spaces round the vessels. This exudate may be so great that it presses on the lumen of the vessels and cuts off the circulation. The grey matter of the anterior horn which is highly vascular shows marked lesions the posterior grey matter often escapes. It may be infiltrated however in some cases especially in the region of Clarke's column. Smaller hæmorrhages occur over a wide area and there is extensive œdema. In the cell itself there is atrophy of the inter cellular network of neurofibrillæ. The cell body swells becomes globular and there is disintegration of Nissl's granules. The cerebrum is affected less frequently than other parts of the nervous system. The cerebral meninges are not usually involved but the medulla and pons may show signs of infection in the form of a marked cellular exudate and many hæmorrhages. Changes similar to those in the spinal cord also take place in the posterior root ganglia and this accounts for the presence of pain in the acute stage.

It will thus be seen that the damaging effect on the cells may result from direct pressure from hæmorrhage exudate or œdema from anæmia through constriction of vessels or from the direct toxic action of the virus.

Changes in the Lymphatic System. The virus has been found to produce extensive pathological changes in the lymphatic tissues and in the parenchymatous organs. The Peyer's patches of the intestines are congested the mesenteric glands are swollen and there is a hyperplasia of the round cells suggestive of typhoid fever. Lymph nodes in other parts of the body are also affected. The spleen is increased in size and shows some hyperplasia of the Malpighian corpuscles while the tonsils are usually larger than normal.

Changes in the Chronic Stage of Poliomyelitis. As soon as the cells become necrotic phagocytes appear and carry away the debris. There is a proliferation of neuroglial tissue replacing the destroyed nerve structures. The neuroglia finally contracts and forms the scars which are seen in the cords of old standing cases. As a result of the destruction of the nerve cells in the anterior horn the peripheral nerve degenerates and the muscles supplied by it atrophy. The extent of

muscular degeneration depends upon the amount of nerve involved. The atrophied muscle fibres are recognized by their yellowish white colour. In some cases complete degeneration is shown by the fatty deposit around the atrophied muscle. Tendons atrophy from disuse become weakened and are prone to yield at the point where they are attached to the atrophied muscles. Bones are also involved in the pathological process—they are more slender than normal with a considerable degree of rarefaction. The medulla is reduced in size and shortening may occur from lack of use and from involvement of the nutritive nerve centres. Joint capsules and ligaments are stretched the joints become unduly mobile and occasionally dislocated.

SYMPTOMS

A Incubation Period

Opinions differ as to the duration of the incubation period. Flexner believed that it varied from two to thirty three days with an average duration of about nine days but recent writers and particularly Aycock and Eaton have shown by investigation that the duration is longer averaging about fourteen days.

B Paralytic Period

The onset of poliomyelitis is accompanied by variable symptoms which may be so slight as to be overlooked until the paralysis develops. During this period the symptoms do not differ greatly from those of any other infectious disease of childhood. Nevertheless the clinical picture in the early stage has certain distinguishing features. As examples of these may be mentioned—the position that the patient assumes to protect himself from pain, the glazed cornea and the rigidity of the posterior muscles of the neck to prevent anterior flexion of the spine.

Draper divides the symptoms of this stage into the general systemic and the meningitic ones. These may run a continuous course until paralysis sets in or there may be two periods of illness, one in which the child appears to recover from the first symptoms of a general systemic infection and after a remission lasting a day or two a second period in which symptoms referable to the cerebro spinal tract predominate. Draper calls this the dromedary type.

(a) Systemic Symptoms. Of all symptoms fever is the most constant, the temperature varying from 100° to 105° or even higher. The pyrexia is of short duration lasting from one to six days. It may subside gradually or by crisis. Pain in some part of the body is marked. It may be spontaneous or elicited by manipulation or there may be a general hyperesthesia of the skin. The pain on either active or passive movement is often so intense that the child lies very quietly and resents any disturbance. It may be localized in the extremities, in the back along the nerve tracks or diffused over the whole body. Muscle tenderness can be elicited after the onset of paralysis. Occipital headaches due to congestion of the cerebral vessels

are common. Hyperæsthesia from early involvement of the posterior root ganglia is marked in the pre paralytic stage. The slightest touch, or even the pressure of the bedclothes, will often elicit pain. Gastrointestinal symptoms, such as nausea, anorexia, vomiting, and diarrhoea, are frequent. Retention of urine may occur. Profuse sweating is common particularly in the severer cases. Congestion of the throat with adenoids and enlarged tonsils, is found. The sclera and cornea of the eye are glazed, in some cases an alternate flushing and pallor of the skin may occur.

(b) Meningitic Symptoms. The patient is very drowsy—and when disturbed is irritable and restless. Convulsions are not common but may occur—particularly in poorly nourished children. In the ordinary spinal type reflexes are exaggerated during the febrile stage. Muscular twitchings may affect a limb in whole or in part, or may involve the whole body. Tremor of the fingers, seen when the hand is outstretched has been demonstrated by Hymen.

(c) The Paralysis. Paralysis comes on, in the majority of cases, about the second day. After the eighth day there seems to be little danger of its appearance or its extension if present. With the onset of the paralysis the reflexes lose their exaggerated quality and finally disappear. The paralysis is usually revealed by examination, unless the child is suffering from such extreme pain that he cannot be persuaded to move his limbs. The extent of the paralysis is determined by manipulation, pinching and pricking the muscles. In the early stage it is widespread, owing to the generalized pressure on the nerve cells from oedema. There may be complete loss of power in the legs, in the back, and in the intercostal muscles. As the oedema in the brain and cord subsides the muscles whose nerve cells are released from pressure gradually recover, the distal muscles recovering before the proximal ones. Paralysis may persist, especially in the lower limbs and abdomen. The upper extremities, being less affected, are more likely to recover than other parts of the body. Recovery, if it takes place, begins within the first two weeks, although it may not be noticed until later. Mild cases may clear up entirely within a week. Muscular atrophy also begins within the first two weeks. The deltoid atrophies more quickly than any other muscle and the prospects of its recovery are remote. A common symptom at this stage is the coldness of the extremities, if not properly protected, the limb may become cyanosed and mottled.

Distribution of Paralysis

The distribution of the paralysis varies greatly, the most peculiar combinations occurring, such as paralysis of the peroneal muscle, and the deltoid, or involvement of the muscles of one leg and one arm. The loss of function is more frequently partial than complete, but cases of complete paralysis are common. According to statistics, the most frequent result is paralysis of one leg, next, paralysis of two legs, while lesions of the upper extremities are comparatively rare.

Paralysis of the bladder may occur particularly in association with paralysis of the abdominal and hip muscles. It may last from a few days to a few weeks but the prognosis is good. Careful catheterization is necessary.

Types of the Disease

In 1917 the New York Health Department suggested the following classification:

- 1 Non paralytic or abortive type
- 2 The ataxic type with nystagmus in which there are pathological changes in Clarke's column, the cerebellum or the basal ganglia
- 3 The cortical type in which the lesion is in the upper motor neuron with a resulting spastic paralysis
- 4 The ordinary spinal or subcortical type in which the lesion is in the lower motor neuron and a flaccid paralysis results

The Ordinary Spinal Type This is the common type. The early symptoms are fever, drowsiness, sweating, headache, gastro-intestinal disturbance, pain, hyperaesthesia and occasionally sore throat and difficulty in micturition or defaecation. There may also be meningitic symptoms such as tremors, twitchings and diminution or loss of reflexes. Rigidity of the neck is important and suggestive while Kernig's sign is usually positive. The paralysis is as a rule demon-



Fig. 6 Infantile Paralysis

The foot appears to be displaced forward and the malleolus a bulky prominence.

strable from the second to the fourth day of the attack, after which time it is less likely to develop. It is flaccid in character. Reaction of degeneration occurs in fourteen days with wasting and fatty infiltration of the affected muscles. Tenderness varies from slight to extreme and is usually more marked in the affected muscles.

A period of spontaneous recovery lasting from six months to a year follows the subsidence of the acute phase. The final paralysis is always less than the initial and is more often partial than complete. If however precautionary measures are not taken during the period of recovery deformities develop as a result of the disturbance of muscle balance. If these are not corrected the surviving muscles atrophy and bone growth is disturbed giving rise to still greater disability and ultimate shortening.

Summary of Symptoms.*Incubation Period*—two to fourteen days*Prodromal Stage*—stiffness of the neck, hyperæsthesia, sweating, and nervous irritability*Acute Stage*—acute illness with rigors, rapid pulse, pyrexia, and quickened respiration, tremors, inco-ordination of movement, retention of urine, occipital headaches, pain and stiffness in the nape of the neck, hyperæsthesia, exquisitely tender muscles, exaggerated reflexes, Kernig's sign present

The full extent of the paralysis is apparent in two to four days, reaction of degeneration in fourteen days

Stage of Convalescence The œdema is now subsiding, but the nerve impulses are finding certain paths blocked. The child tries to use the affected limb, the tenderness has gone, and there is a continual gain in muscle power. This stage lasts about two years.*Chronic Stage* The œdema has disappeared and with it the perivascular infiltration. The meningitis has passed and there is now focal gliosis. Clinically the case is now stationary or regressing.**DIAGNOSIS**

The development of a spastic state of the posterior neck muscles on attempted flexion of the head is a sign of great diagnostic importance in the acute stage, and one of the last to disappear. Jones and Lovett point out that

an acute infection in a young child in the late summer, in a region where the disease is prevalent, is suggestive, especially if accompanied by sweating, nervous irritability, stiffness, or hyperæsthesia.

The presence of these signs and symptoms calls for a lumbar puncture, about 10 c.c. of fluid being withdrawn. The cerebrospinal fluid in acute poliomyelitis is usually clear, and flows under increased pressure. As a rule there is a definite increase in the number of the cells—the normal fluid containing from 5 to 10 cells per cubic millimetre, while in poliomyelitis this may be increased to hundreds or



FIG. 227.—Infantile Paralysis. Atrophy of the deltoid muscle.

even thousands per cubic millimetre, being highest during the first week. The predominating cell in the early stages is similar to the polymorphonuclear leucocyte but after meningeal invasion the polymorphonuclear gives place to mononuclear cells chiefly of the lymphocytic variety. Globulin and albumen are increased. The excess of globulin is slight during the early stages but the content rises gradually till the third week, when it is most marked. A slight reduction of Fehling's solution is obtained in the majority of cases. After the development of paralysis the diagnosis presents little difficulty flaccidity of a whole limb being obvious. Paralysis of individual muscles is discovered by careful examination.



FIG. 28.—Infantile Paralysis. Severe affection of the right arm.

DIFFERENTIAL DIAGNOSIS

Diseases which may simulate Anterior Poliomyelitis are grouped under four heads.

1. Acute Fevers without Paralysis

(a) *Typhoid*. In the early stages the diseases may resemble each other but later a positive Widal reaction and finally the absence of paralysis serve to differentiate them.

(b) *Rheumatism*. Here there is acute hyperæsthesia and fever just as in poliomyelitis but it is obviously a joint infection, may be poly-articular, and recovers quickly under treatment.

(c) *Respiratory Diseases* These usually occur at different times of the year and affect adults more frequently than children. Catarrhal symptoms are absent in poliomyelitis.

2 Other Diseases of the Nervous System

(a) *Encephalitis Lethargica* This primarily presents cerebral symptoms and only in exceptional cases is there involvement of the spinal cord. It attacks persons of all ages, is more prevalent in winter and varies in its period of onset.

(b) *Cerebral Thrombosis* Local signs such as cyanosis of the face, oedema of the eyelids and face and protrusion of the eye are suggestive of this disease.

(c) *Acute Transverse Myelitis* The gait is spastic, the muscles atrophy slowly and a progressive paralysis without remission develops.

(d) *Tuberculous Meningitis* The general appearance of the patient, the irregular temperature curve and the duration of the prodromal period point to this disease rather than to Poliomyelitis. As a rule a spinal puncture is necessary for a final decision.

(e) *Spina Bifida*

(f) *Spastic Paralysis*

(g) *Hereditary Ataxia*

3 General Diseases with Pseudo paralysis or Spasm

(a) *Pseudohypertrophic Muscular Dystrophy* This disease is characterized by its slow onset and lack of interference with reflexes. There is a marked increase in the size of muscles especially those of the calf. It is a rare disease in childhood.

(b) *Scurvy, rickets* and *Lysteria* rarely present any difficulty.

4 Conditions with Loss of Power due to Lesions other than Poliomyelitis

Congenital Club foot, Congenital Dislocation of the Hip and *Tuberculosis of the Hip* must be remembered in this connection.

PROGNOSIS

1 As regards Life This is based on the site and extent of the paralysis and the occurrence of complications particularly pneumonia. Wakeman found the mortality in patients under 11 years of age to be 11.9 per cent and in those between the ages of 12 and 32, 27.6 per cent. Severe illness with high fever in the initial stage is of grave



FIG. 2-9—Infantile Paralysis of the right leg affecting especially the calf muscles.

portent Peabody believed that the mental reaction of the patient is a factor to be considered in prognosis. Patients with stupor rarely die but alert cerebration on the part of a child is of serious import. The fatal cases occur in those of the overwhelming toxæmic type and in the ascending spreading type. Death is unlikely after the eighth day of the paralytic period.

2 As regards Function No data exist on which to base prophecy of the ultimate effect on function. The amount of recovery is dependent upon the state of the cord and particularly upon the treatment adopted but the physician may safely predict an improvement in the condition. Recovery may be rapid during the first few days or weeks because of the absorption of the inflammatory oedema in such cases the prospect of complete recovery is favourable. In other cases the paralysis may disappear gradually. The factors favouring recovery apart from the healing of the actual lesion are (1) initial rest (2) the prevention of deformity and muscle stretching (3) careful muscle training and massage instituted at the proper period and (4) such mechanical treatment or operative interference as is indicated in special cases.

TREATMENT

1 Prophylaxis

As the disease is now notifiable it is probable that large epidemics will be rare. Certain precautions should be taken during the progress of any epidemic. Ordinary care and cleanliness especially as regards nasal secretions should be observed. Patients should be isolated and crowds should be avoided. The handling of pets should be forbidden. Good results are recorded following the intra nasal spraying of 1 per cent zinc sulphate in physiological salt solution with the addition of 0.5 per cent pontocaine to prevent pain or discomfort. It has been found by experiment that one attack confers immunity. While serum from a convalescent patient is virucidal it is not yet possible to increase the penetration of the serum into the central nervous system or to form a hyper immune serum. The results from the use of attenuated serum are variable a vaccine capable of conferring immunity being still virulent enough to kill monkeys.

2 Treatment during the Acute Stage

(1) Serum Treatment

(a) *Convalescent Serum* Convalescent serum is of very definite value and in the 1932 epidemic in Australia the results were beyond all expectation. It prevents the complete destruction even of threatened nerve cells. The blood of the donor of the serum and that of the patient must be compatible and a Wassermann test should be performed on the donor. The best method of administration is by combined intravenous and intraspinal injection. 50 c.c. of the serum being administered in children up to 2 years of age 20 c.c. intrathecally.

and 30 c c intravenously, and larger amounts in older patients. In intraspinal injections, the amount of serum administered varies with the quantity of spinal fluid withdrawn and with the pressure. It should never exceed the amount of fluid withdrawn.

(b) *Immune Horse Serum* Rosenow and his workers especially Nichol claim to have developed a curative serum by injecting strains of the pleo morphic streptococcus into the horse. They maintain that a lowered mortality rate follows its use, and that residual paralysis is less. One thousand one hundred and thirteen cases were treated, with 278 controls, and the effect was independent of spinal drainage. They have, however, failed to convince other bacteriologists.

(c) *Normal Sera* Normal sera, whether of human or animal source, are supposed to be of value in producing an increase in the polymorphonuclear leucocytes in the spinal fluid. The number of patients treated in this way is insufficient to justify the drawing of definite conclusions.

(2) **Lumbar Puncture** is frequently performed to relieve pressure. Fluid is allowed to escape until only an occasional drop appears. This would seem to be a much more efficacious method of reducing cerebro spinal pressure than the use of hypertonic solutions.

(3) **Sulphonamides** have been used in an epidemic of poliomyelitis by Rhett, and although the results are not easily interpreted some benefit seems to have followed the administration.

(4) **Complete Functional Rest** is enforced during the early part of the paralytic period. Inactivity aids Nature in her attempt to allay inflammation and restore the exhausted nerve centres. Active movement, such as massage or manipulation, is contra indicated during this period. There is reason to believe that manipulations of the spine, such as are practised by osteopaths and chiropractors, prejudice the chances of recovery. Rest should be efficient and prolonged. The patient should lie recumbent and if the extent and site of the paralysis make it advisable, a plaster shell may be applied.

(5) **Local Heat** Pain and tenderness may be relieved by the application of heat in the form of radiant heat baths or local hot baths. These improve the general circulation by producing hyperæmia.

(6) **Prevention of Deformity** Every effort should be made throughout this stage to prevent deformity. Any muscle which shows weakness or paralysis should be placed in such a position that it is free from tension. Sometimes it happens that crises occur in which there is already slight deformity, and that the attempt to correct this causes discomfort or even pain. In such a case, it may be wise to abstain from efforts at correction, lest the tenderness and paralysis be increased by irritation of the affected nerve centres. If possible, however, every affected joint or limb should be placed in the position of maximum functional utility.

(7) The Kenny Treatment in the Acute Stage

A new method of treatment remarkable in its concept no less than in its results has apparently been under trial in recent years in Minneapolis. It is devised by Miss Kenny an Australian and sponsored by various governments in that country where a number of Clinics have been established in which the treatment is carried out. It is of most value only if the treatment is started early in the disease.

Although the usual idea that there is damage to the anterior horn cells and flaccid paralysis is accepted Miss Kenny believes that something more than this occurs that the major symptoms early in the disease are not so much flaccid paralysis but are three other symptoms—muscular spasm inco-ordination and another condition mental alienation.

Muscular spasm is a group of symptoms including fibrillary twitches hyperirritability to stretching and a tonic state of contraction of the fibres often not overcome even by great force. The spasm most commonly occurs in the hamstrings but also in the back muscles pectoralis gastrocnemius etc.

Inco-ordination is described by the Minneapolis group as of two types

(1) that due to the spreading of motor impulses intended for one group to another due to pain in the involved muscle or inability of that muscle to perform its proper function

(2) that occurring within the involved muscle so that ineffective contraction is produced instead of co-ordinated rhythmic contraction producing maximum motion at the insertion of the muscle.

The third of the major symptoms is *mental alienation* and is described as the inability to produce a voluntary purposeful movement in a muscle in spite of the fact that the nerve paths to that muscle are intact. Cole and his associates say that an example of mental alienation not due to infantile paralysis frequently seen by the orthopaedic surgeon is the inability of some patients to contract the quadriceps after a knee operation. In a case of foot drop from infantile paralysis Miss Kenny states that the gastrocnemius is in spasm and the dorsi flexor muscles are mentally alienated.

Treatment The patient is placed in bed in what is called the basic position on a firm mattress with bed boards and a foot board propped away from the end of the mattress by four inch wooden blocks so that the patient when he is in the prone position can extend his toes over the end of the mattress. The footboard is to maintain the normal standing reflexes and not in any sense a splint. Spasm is treated by the application of hot fomentations or packs. The joints are never covered but the affected muscles are wrapped in hot packs and renewed every two hours or it may be even every fifteen minutes if the spasm is acute. If the gastrocnemius muscle is in spasm the foot is not placed against the footboard because it is believed that

stretching of the muscle in spasm aggravates the condition. When hot fomentations are applied for treating spasm of the abdominal and lower back muscles the thighs are flexed to relax the psoas. Massage is never employed. In the early stages passive motions to the extent that can be obtained without producing pain are carried out every day. Re-education of muscles is based on the concept described, the purpose being to restore connection of the part with the central nervous system, or, in other words, to restore mental awareness. As spasm decreases the education progresses from the early passive movements to more active exercises. Actual re-education is not attempted until painful spasm is eliminated. When any visible or palpable motion is accomplished the treatment is stopped immediately in order to leave with the patient the memory of the accomplishment. If there is no trace of motion in spite of the absence of spasm the reflexes are stimulated by placing the muscle slightly on the stretch and then stimulating the muscle. Cole and his associates point out that muscle re-education depends upon—

- (1) the relief of spasm
- (2) the teaching of muscle awareness,
- (3) the combating of inco-ordination and alienation,
- (4) the retraining of nerve pathways back to the non-functional muscles

Many orthopaedists in America and Australia are apparently convinced of the efficacy of this Kenny method of treatment.

3 Treatment in the Convalescent Stage

This stage begins with the subsidence of the acute symptoms and lasts up to the time when the paralysis is stationary. The duration is usually about two years. Every patient is a social and economic problem and the surgeon should from the onset, formulate the plan which will bring the patient to adult life with the maximum of functional efficiency. The treatment, therefore, must be prefaced by a careful estimation of the damage that has been done by the disease, noting the muscles that are paralysed and those that are weakened and charting the results of the examination. When this has been done it is possible to plan the future, or, at any rate, to anticipate any possible deformity that might be caused by the paralysis and to attempt to prevent it.

The object is to restore the greatest possible amount of efficiency to the atrophied muscles and it is to be remembered that since many of the nerve centres are only temporarily affected, a great improvement will ultimately take place. The treatment has three important phases. The first is symptomatic, the second, and most important, is the prevention of the development of deformity, and the third is the restoration of function. The first question that calls for decision is whether the patient should be treated in bed or allowed to get up. There are reasons for and against recumbent treatment. There is no

doubt that the circulation is much more sluggish in bed, and that sitting up stimulates the muscles to a certain extent. The danger of some pulmonary infection is much greater with recumbency. Nevertheless, when there is any great degree of paralysis particularly of the trunk or the hip muscles, it is infinitely better to rest the child completely in bed in the supine position, as the muscles are more likely to recover and there is certainly less likelihood of the development of serious deformity. It is probable that many of the cases of paralytic scoliosis, so frequently met with, would never have occurred if recumbency had been insisted on from the first. Exercises for the muscles are beneficial, and non weight bearing exercise is distinctly better than that which in addition to using its power for movement, has also to bear the superincumbent weight of the body. If the paralysis is not extensive, and it is decided that the patient may get up some form of brace or jacket should be fitted to relieve the weakened muscles from the strain of weight bearing. Otherwise the patient is easily fatigued, and his muscles consequently injured.

Deformity is the most serious complication at this stage, but it seldom develops if simple precautionary measures are adopted. The factors concerned in the development of deformity are (1) disproportion in muscle balance, (2) muscle contracture (3) habit posture, and (4) gravity. There are three stages to be noted. First, a postural mal position due merely to muscular weakness. In this phase the limb can be replaced in its normal position easily, without force. In the second stage there is shortening of the soft parts on one aspect of the limb, and lengthening on the opposite side. The third stage is that of permanent bony deformity which occurs when the mal position has remained unaltered for some years. To avoid deformities some form of apparatus should be used. This not only prevents deformity, but may correct it. It certainly prevents the stretching of paralysed muscles and in many cases permits of or improves, walking.

Apparatus used in the Convalescent Stage

During the ambulatory stage it is wise to use some form of apparatus to prevent the development of deformity. The form of apparatus varies with the types of paralysis that arise. The following, in particular are frequently employed.

(1) *The Abduction Splint*. This is useful in cases of shoulder paralysis where it is essential to keep the arm fully abducted. It is also called the 'aeroplane' splint, and has a supporting band round the pelvic girdle and in extension from the region of the axilla to keep the arm in full abduction. The elbow can be kept in any desired



FIG. 230.—Infantile Paralysis. Medial iron and lateral T strap for use in peroneal paralysis. The strap and iron may be transposed for use in other deformities.

position A "cock up" splint is usually fitted for the wrist and fingers

(2) *The "Cock up" Splint* This is useful in cases of drop wrist in which the extensor muscles are involved It may be of either the short or long type, the short being used solely for the wrist extensors while the long form is used where the extensors of the fingers are also affected The application of a plaster of Paris case is probably more efficient and a better functional position of the fingers can be ensured

(3) *The Walking Caliper* This is a modification of the Thomas knee splint in which the ends of the splint are angled to fit into a metal box in the heel of the boot

(4) *A Back Brace* Where the muscles of the back are involved, a brace or close fitting corset, or a combination of both, lessens the strain, and prevents the possible development of scoliosis If the abdominal muscles are paralysed, the addition of a corset prevents muscle stretching

(5) *A Drop foot Splint* The drop foot splint is shorter than the walking caliper, reaching to a point below the knee joint It consists of an encircling band below the knee, with two irons extending downwards from it to the heel of the boot These fit into the heel by a square socket, so that foot drop is prevented This is known as a right angled stop joint

(6) *Raised Heel with Strengthened Tongue* When the muscles of the calf are paralysed it is essential to guard them from overstretching To this end the heel may be raised by about $\frac{1}{2}$ inch and a metal lining inserted into the tongue of the boot This prevents any dorsiflexion of the foot and consequent stretching of the paralysed muscles

(7) *Lateral Iron and T Strap* In cases of paralysis of either the peroneal or the anterior or posterior tibial muscles, a medial or lateral iron with a lateral or medial T strap respectively, should be fitted to the leg This instrument differs from that used for drop foot in having only a single lateral iron, it is extremely useful in preventing deformities at the ankle

Active Therapeutic Measures

(1) *Massage* Massage is of undoubted value in infantile paralysis, since it stimulates the flow of both venous and arterial blood as well as of the lymphatic stream The muscles are directly manipulated and so emptied of any waste products The massage retards and counteracts muscle atrophy by improving local nutrition Rough handling however, may easily increase atrophy and paralysis

(2) *Heat* A warm muscle acts more efficiently than a cold one The heat moreover, adds to the effectiveness of massage It may be applied either as a radiant heat bath or a warm water one

(3) *Electrical Stimulation of Muscles* The paralysed muscles, though at first they do not react to the faradic current, respond to galvanism and one of the most effective methods of preserving nutrition in a

paralysed muscle is to induce contraction by this form of stimulation. Each muscle is picked out in turn by an electrode and a series of contractions produced. The faradic current is used as soon as the muscle by its response shows signs of recovery. Great care should be taken to avoid fatigue by over stimulation.

(4) *Muscle Training* The re education of a muscle establishes better co ordination between the remaining nerve fibres supplying it and secures a certain degree of contraction which however feeble is the best possible treatment of the muscle itself.

The patient concentrates his attention on the attempt to accomplish the desired movement while it is performed passively. It is often helpful to get him to perform the same action on the healthy limb. When the muscle becomes capable of spontaneous action a little additional resistance should be given so as to increase the strength of the contraction. When the patient is a child every effort must be made to aid concentration by exciting interest and preventing boredom. Treatment in a large water pool or tank is very helpful, and certainly boredom is avoided. The water helps to support muscles too and in that way they are less likely to be strained. When the time comes for active muscular movements to be performed the patient is placed in a warm bath and movements are performed there. In this way it is possible to give voluntary exercise to muscles which in the air the patient would still be unable to move.

It is thus apparent that at this stage the main essentials of treatment are the avoidance of stretching and fatigue of muscles and the prevention of deformity. The surgeon is often consulted as to the most suitable type of athletic exercise. Cycling and swimming may be recommended as being freer from risk than more strenuous pastimes.

TREATMENT OF ESTABLISHED DEFORMITIES

1 Dislocation of the Hip

Paralytic dislocation of the hip is particularly common in infantile paralysis. It follows flexion deformity especially that associated with adduction. The relaxation of the joint capsule facilitates dislocation. The dislocation may be incomplete giving rise to what is known as a snapping hip. The diagnosis is not difficult as the head of the femur slips from the socket whenever the leg is adducted. The condition causes great lameness and occasionally much irritability of the joint.

Probably the most important factor in the treatment of these cases is prevention. Flexion and adduction should be prevented by conservative methods and these patients should acquire the habit of sitting and sleeping with their knees separated—the abduction being more important than extension in the prevention. The best splint is

made from two half cuffs of metal joined together by a metal rod about 12 inches to 18 inches long attached to the middle of their convex surfaces. This is bandaged on nightly to the patient's legs just above the knees. In addition to the steps taken to reinforce the paralysed muscles—usually the glutei—two methods are employed in the treatment of the actual dislocation.

(a) **Shelving Operation** If there is any difficulty in reducing the hip the contracture is relieved by fasciotomy. Thereafter the hip is reduced. Through a Smith Petersen approach a shelf is turned down from the side of the ilium. The shelf should be accurately placed on the upper and posterior part of the acetabulum and be of a more massive type than in the operation for congenital dislocation. The actual method is described under the treatment of a congenital dislocation of the hip in Chapter II (page 31).

(b) **Arthrodesis** Arthrodesis may be indicated if it appears certain that a stiff hip will assist locomotion. Many of these patients have other deformities and paralyses which would annul the possibility of this benefit so that careful consideration must be given to each case before an arthrodesis is recommended. In some cases however it may be justifiable. The usual method of arthrodesing the hip is by exposing the joint and denuding the acetabulum and head of cartilaga and producing good apposition and immobilization by a tri fin nail. A plaster of Paris spica is of course also necessary.

2 Hip Flexion Contracture

This results from contraction of the tensor fasciæ latæ the ilio psoas the sartorius and the rectus femoris. It rarely occurs alone being frequently associated with abduction of the hip flexion deformity of the knee and talipes equinus of the foot. It may be obviated to a certain extent by placing the patient in the prone position for some hours daily during the earlier stages of the disease. Once the deformity has developed it may be treated in one of two ways—either by stretching the paralysed tissues or by division of these structures by open operation. Each method has its advantages and its advocates. Stretching is said to be unreliable because of the nervous irritation produced and because of the local pain. Further it damages other tissues and may interfere with the circulation. On the other hand division of a shortened muscle or erosion of its normal origin leaves it very much weakened. The surgeon must come to a decision after careful consideration of the stage of contracture and the general condition of the patient as regards other deformities in the limb. The author uses the gradual stretching method in mild contractures in severe cases and in cases which resist stretching he performs the Soutter type of operation.

(c) **Gradual Stretching by the Agnes Hunt Method** In correcting a flexion deformity of the hip by stretching the compensatory

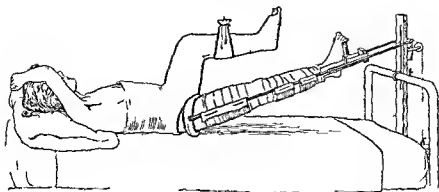


FIG. 231.—Infantile Paralysis The Agnes Hunt Plaster Method of correcting Flexion Deformity of the Hip

spinal lordosis induced by previous treatment must be overcome. This is effected by the following method—any lordosis is corrected by flexion of both hips, the spine and unaffected hip and leg are then immobilized in plaster of Paris. The affected limb is now fixed in a Thomas's knee splint and traction made on it, the splint being gradually lowered as the tight structures yield to the extension. When the limb has been brought down to the extended position, the plaster is removed. If both hips are contracted, the spine and the corrected limb are then put in plaster and the same corrective measures carried out on the other leg.

(b) **Open Division and Fasciotomy** In certain cases where the above method has failed, it may be necessary to divide the tensor fasciæ latæ. This is followed by manipulation, repeated if necessary, and is frequently attended with very good results.

(c) **Soutter's Operation** By this method, the flexors of the hip are stripped subperiosteally from their original position, and allowed to slip down the side of the pelvis. This permits of full extension of the hip.

Technique A vertical incision is made from 2 inches above the anterior superior spine downwards along the anterior edge of the tensor fasciæ latæ for about 4 inches. The fascia is exposed and divided in a line from the greater trochanter to a point near to the anterior superior spine. The muscles are then stripped from the spine subperiosteally by an elevator. The separation extends backwards on both sides of the crest for about $1\frac{1}{2}$ inches, and downwards on the anterior surface of the ilium as far as the anterior inferior spine. The thighs are then extended. In most cases the deformity is in this way completely corrected. In more severe cases it may be necessary in addition to divide the iliopsoas muscle. This can be reached in the depth of the wound by following the neck of the femur down to the



FIG. 232.—The Schwartz Frame in use in correction of severe Hip Flexion Deformity following Infantile Paralysis

lesser trochanter after retracting the sartorius medially and the tensor fasciæ latæ laterally. In still more severe cases it may be necessary to divide the anterior portion of the capsule of the hip joint. The anterior superior spine and part of the crest of the ilium left bare in the wound when the thigh is extended, are now cut off flush with the surface and the wound closed.

AFTER TREATMENT

The patient is placed either on a Schwartz frame or in a plaster spica with the hips hyperextended for two or three weeks until the wound is healed and the muscles have become united to their new attachments.

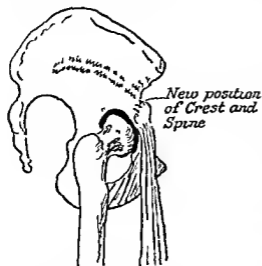


FIG. 233.—Flexion contracture of the Hip; Campbell's Muscle-sliding Operation for Reduction of the Deformity

(d) Campbell's Operation. This is a modification of Soutter's and is reserved for the most severe cases. The anterior superior spine and the anterior portion of the crest are detached along with their attached muscles slipped down and reinserted at a lower level.

Technique. The operation is carried out through a Smith-Petersen incision. The superficial and deep fasciæ are incised over the

crest of the ilium to the anterior superior spine. The latter is detached with a chisel along with a part of the outer table of the crest which is split off for some distance from before backwards. Along with this piece of bone the entire muscle mass is separated subperiosteally until the rim of the acetabulum is reached. Immediately above the rim a groove is chiselled into the bone and into this groove the detached portion of the iliac crest with its adherent muscles is implanted. The deformity can now usually be corrected if not the psoas and the anterior portion of the capsule are also divided. The deep fascia of the upper edge of the wound is sutured to that of the lower flap in such a manner as to draw the skin wound downwards about 1 inch below its original level. In this way a scar directly over the raw crest is avoided and pressure on the unprotected bone prevented.

The after treatment is the same as before. The plaster case is retained for about eight weeks. Campbell calls this operation the transference of the iliac crest.

3 Deformities of the Knee

(a) *Flexion Deformity* This occurs where there is paresis of the anterior thigh muscles with over action of the posterior group. The deformity can be prevented by the use of a Thomas's knee splint and frequently this splint may be used also to correct the condition when applied along with plaster traction on the side of the leg.

METHODS OF REDUCTION OF THE ESTABLISHED DEFORMITY

(1) *Wedge Plaster Method*

A circular plaster is applied to the leg from the toes up to the groin in the position of the deformity and allowed to harden. A transverse slit is then made through the posterior three quarters of the plaster at the level of the knee joint. Thin pieces of wood are now inserted into this slit to force it open, the leverage being so favourable that the knee may be straightened out quite quickly. An instrument devised on the lines of a rib spreader is used by the author to force open the divided plaster.

(2) *Operation — Tendon Lengthening* This operation

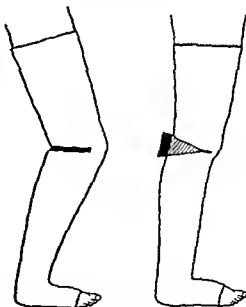


FIG. 34.—Infantile Paralysis. The method of correcting a flexion deformity of the knee by Wedge Plasters.

may be carried out by a single longitudinal and mesial incision in the popliteal space or by two separate lateral incisions. The *semmembranosus*, *semitendinosus*, *gracilis* and *sartorius* muscles are lengthened on the medial aspect and the biceps and tensor fasciæ latæ on the lateral. Directly in the line of the incision in the fascia of the popliteal space are the posterior tibial artery and the superficial peroneal nerve at a deeper level is the popliteal vein and still deeper the artery. These structures must be carefully avoided. Each of the tendons is lengthened in the usual Z shaped fashion and after closing the wound the leg is put up in a straight back splint.

Wilson has recently shown that many of the cases which result correction by other means can be treated satisfactorily by a capsuloplasty of the posterior part of the capsule of the knee joint. Apparently this tends to be very short in flexion contracture.

(b) **Knock Knee** This deformity is often seen as a result of paralysis of the quadriceps and may be due to the stronger pull of the hamstring muscles and particularly that of the tensor fasciæ latæ. Prophylactic measures should be adopted in cases in which the deformity is likely to develop. In these cases the application of a plaster case may help.

Mild cases may be overcome by manipulation and traction recurrence being prevented by the application of a caliper splint fitted with a knock knee strap to secure leverage. If knock knee is greater than 8 degrees an osteotomy is indicated and should yield very satisfactory results.

(c) **Genu Recurvatum** This develops in cases of paralysis of the quadriceps when the patient fearing that the knee will give way attempts to make the leg stable by locking the joint in hyperextension before bearing his weight on it. The posterior part of the capsule and the posterior muscles become stretched. The prognosis is not good in these cases but a caliper with a posterior knee strap is a satisfactory form of support sometimes in addition a Jones's knee brace may be used.

Campbell's Operation for Genu Recurvatum Campbell recently described a bone check operation in which the patella is used to prevent the occurrence of the deformity. A U shaped incision round the patella is made with the transverse bar of the U just below the attachment of the ligamentum patellæ. The flap is reflected upwards and the patellar ligament and patella exposed. The ligament is completely excised and a raw surface made on the lower end of the patella. A further raw area is similarly prepared on the anterior aspect of the upper end of the tibia and united to that on the patella the knee being flexed at 160 degrees. After closing the wound the limb is encased in a plaster of Paris spica. When satisfactory union has occurred between the patella and the tibia it will be found that the patella forms a complete check to any hyperextension at the knee joint.

Arthrodesis Cure of the deformity can be effected by this operation, but it is rarely necessary to resort to it

4 Deformities of the Ankle Region

(1) *Talipes Equinus* or *Drop Foot*. This is one of the commonest deformities produced in poliomyelitis. It usually develops in cases of paralysis of the extensors of the foot, but may be static in origin, being compensatory to shortening of the leg.

Slight shortening of the tendo calcaneus is an advantage in some cases of infantile paralysis, e.g. in cases with quadriceps insufficiency and where there is shortening of the limb. When weight is borne on a limb with a weak quadriceps, the strain on the gastrocnemius muscle locks the knee joint and so increases its stability. For this reason, the tendo calcaneus should not be divided or elongated without careful consideration, lest the stability of the leg be imperilled. In some cases, however, elongation of the tendo calcaneus is necessary to allow relax-



FIG. 235—Types of Foot Deformity

(A) *Talipes calcaneus*.
(B) *Talipes equinus*.

(C) *Talipes valgus*.
(D) *Talipes varus*.

ation and recovery of the weakened anterior leg muscles. It is elongated sufficiently to permit of a right angled position of the foot. If a greater degree of lengthening results from the operation, a flail foot may result. In the later stages, therefore, when the anterior group of muscles is completely paralysed and there is no hope of recovery, this accident is guarded against by performing a tenodesis or arthrodesis in addition to lengthening the tendon.

Lengthening of the tendo calcaneus by Open Operation

A vertical incision 6 to 8 inches in length is made on the medial aspect of the tendon from its insertion into the calcaneus directly upwards. The incision lies in front of the tendon. The synovial sheath is incised in the line of the skin incision, the tendon exposed, and divided into anterior and posterior halves by a long lateral vertical splitting incision. At the lower end, the anterior half is detached from its insertion into the calcaneus, while at the upper end a transverse incision is made through the posterior half of the tendon. In this way two broad flaps are secured which form broad surfaces for

coaptation after the deformity is corrected. The foot is now brought into the right angled position and the two flaps of the tendo calcaneus are stitched together in their new position by either linen thread or chromic catgut. The sheath is carefully sutured over the tendon and the skin incision closed.

AFTER TREATMENT

Immobilization following tendon lengthening should be maintained for six or eight weeks by a plaster of Paris casting the foot being at a right angle. At the end of this period the tendon should be completely healed and thereafter a strong boot will suffice.

5 Deformities of the Spine

Scoliosis In the early stages the back should be watched very carefully and steps taken to prevent the onset of this deformity. The preventive treatment should begin while the patient is in bed; he should be placed on a rigid fracture board or even a Whitman frame until the end of the convalescent period. Thereafter he should be supported by a light spring back brace or a leather jacket. If no improvement in the paralysed muscles takes place within a reasonable period it may be assumed that they will not recover in which case fusion of the vertebræ by operation is recommended if the child is of a suitable age.

Once the deformity has developed an attempt should be made to reduce the curvature as far as possible. The method described by Abbot and carried out by means of a plaster jacket is of some value although the treatment is arduous and tedious and the result uncertain. When the deformity has been corrected as far as possible operative fusion of the vertebræ should be carried out either by Hibbs's method or by a modified Albee's operation.

6 Deformities of the Shoulder

Paralysis of the deltoid is the common affection in this situation and results eventually in an adduction contracture. The arm dangles at the side and only swinging movements are possible.

The shoulder in the early stages should be retained in the abducted position by a splint or a plaster of Paris shoulder spica. After a few months the upper half of the shoulder piece of the spica can be removed and hot air treatment, massage and passive exercises instituted to strengthen the muscles. Where the arm cannot be brought to the abducted position because of an adduction deformity an open operation may be carried out. Through a vertical incision similar to that used for exposing the shoulder joint the various adducting muscles are tenotomized.

*CHRONIC STAGE OF POLIOMYELITIS***TREATMENT**

So far the surgical measures which have been described in the treatment of this disease have been designed to correct deformity, so that the over stretched, paralysed muscles get a chance to recover, and the various joints can be placed in a position which will allow complete mobility when the chronic stage is reached. It will have been noted that these procedures are manipulation, fasciotomy, tenotomy, tendon lengthening and osteotomy, the selection of the appropriate operation depending upon the degree and site of the deformity.

In the chronic stage a different type of operation is performed, one which has for its object the unimprovement of function. Indeed, at this stage functional improvement is the only indication for operation. It would be of little use, for instance, to stabilize the shoulder joint in a position of abduction if the rest of the arm were completely paralysed. This operation would be indicated only if the fingers retained some power to grip. The operations that are carried out are grouped into two main types, the first, those that improve muscle balance, the second, those that secure stability. These measures, with one exception, should not be used until two years have elapsed from the onset of the disease, for during this period there is always a possibility that muscle power will improve under conservative treatment. The exceptional case is one which shows increasing deformity. This type of treatment is better carried out when the child is at least 7 or, better still, 12 years of age, as by that time re-educational exercises are more readily learnt.

1. The Improvement of Muscle Balance.

Muscle and Tendon Transplantation. A tendon transplantation aims at replacing the paralysed muscle by a normal one which is physiologically able to act as its substitute. Transplantation is also designed to restore muscle balance, to prevent or correct deformity, and to improve stability, in conjunction with such operations as arthrodesis, etc. Although it is the most generally useful and most satisfactory operation in unimproving function, results do not generally come up to expectations. Some transplantations, however, give uniformly good results, particularly transplantation of the flexor muscles of the forearm for paralysis of the extensor group. There are certain important points in the technique of these operations.

(1) The deformity must be corrected before the transplantation is performed. Occasionally this can be carried out at the time of operation. It may be possible, for instance, to manipulate the limb into the desired position, after the tendons to be transplanted have been divided.

(2) The tendon to be transplanted must be taken from a healthy muscle, and should be more or less equal in strength to the muscle

it is to replace This is more important in the lower than in the upper extremity in the latter the question of stability is of minor importance

The function of the tendon to be transplanted should resemble that of the paralysed muscle Results are sometimes disappointing when antagonistic muscles are used for transplantation

(3) The tendon to be transplanted should pass through subcutaneous fat, or, preferably, through a tendon sheath, so as to avoid friction which might interfere with its smooth movement

(4) It should also pass more or less in a straight line To this end it may be necessary to make large holes in the fascia Where the tendon proves too short to meet the point of insertion, the gap may be bridged by fascia lata or silk, or a free tendon transplant

The Insertion of the Tendon In all transplantations in the lower limb, with one exception the transplanted tendon should be inserted into bone Usually a small piece of bone is elevated, the tendon fixed beneath it and the bone replaced In this way a firm insertion is obtained The exception is the transplantation of the posterior tibial or peroneal tendons into the tendo calcaneus to strengthen the calf muscles In the upper extremity, where there is less strain, tendon to tendon attachment may be used The transplanted tendon is inserted so as to be under considerable tension

The Operation As cases vary so widely routine operations are impossible, each case is a separate problem A certain number of operations which are more or less stereotyped will be mentioned later

A CONSIDERATION OF REGIONAL DEFORMITIES

Deformities of the Foot

Transplantations of tendons in deformities of the foot are mostly used in conjunction with stabilizing operations upon the bones Inversion or eversion deformities of the foot must be corrected or prevented permanently in order to have maximum function and freedom from pain These are much more difficult to treat and are more disabling than talipes calcaneus and equinus Even in spite of splints the feet roll into inversion or eversion, and painful callosities develop over prominent bony points from friction or pressure of the splint The only means of combating this deforming tendency successfully is by operative fixation of the foot in the subtaloid articulation, accompanied, where possible, by the transplantation of the good muscles to positions of more useful function Stability on weight bearing is of prime importance, and the conviction that this stability can be insured permanently only by bony fixation is becoming more firmly implanted every day

(1) **Talipes Varns** This results from paralysis of the peroneal muscles the foot becoming inverted by the action of the strong tibialis anterior and posterior. In such cases the tibialis anterior tendon after being freed from its insertion is fixed sub periosteally into the cuboid on the lateral side of the foot. This greatly improves function, but some form of bony arthrodesis is more certain of controlling such a lateral deformity.

(2) **Talipes Valgus** This results from a paralysis of the tibial muscles. The peronei overact and pull the foot into an everted position. In these cases one of the peroneal tendons may be inserted sub periosteally into the navicular on the medial aspect of the foot. This is particularly useful as a supplement to a talo navicular arthrodesis but is rarely satisfactory when performed alone.

(3) **Talipes Calcaneus** This is due to involvement of the gastrocnemius muscle. Although transplantation of the peroneus longus or the tibialis anterior into the tendo calcaneus is useful in mild cases some stabilizing operation such as a Whitman astraglectomy is indicated in the severe types.

(4) **Talipes Equinus** In mild degrees of this deformity the peroneal tendons and the tibialis posterior may be transplanted into the dorsum of the tarsus. Where the deformity is severe one or more of the following procedures may be used: (1) backward displacement of the foot as in the Hoke or Dunn operation; (2) lengthening of the tendo calcaneus; (3) tenodesis using the inactive peronei and the tibialis anterior for implantation into the tibia; (4) bone block operation for drop foot (Campbell).

Tendon Transplantation at the Knee Joint

Quadriceps Paralysis When this muscle is paralysed transplantation may be carried out to increase the stability of the knee. When the flexor group is carried forward to take the place of the paralysed quadriceps there is an increase in stability but the new extensors have little functional value. There are several muscles available for transplantation. The biceps femoris is the one most commonly chosen but when any of the flexor group is taken care must be exercised to make sure that the gastrocnemius which acts as a flexor is functioning or at least that one flexor with good function remains. Two operations are described.

(a) *Transplantation of the Sartorius into the Patella*

A curved incision is made extending from the middle of the medial side of the thigh over the top of the patella to the lateral side of the knee. The sartorius is cut opposite the patella freed from the surrounding muscles as far as the middle of the thigh and its end is sutured with chromic or linen suture. A slit is made in the lower quadriceps tendon above the patella and through this the sartorius is

drawn and brought down to the patella where it is attached subperiosteally. It is also sutured to the quadriceps for 3 inches by interrupted catgut sutures. The wound having been closed and the knee extended, a plaster bandage is applied from ankle to groin.

(b) Transplantation of the ilio tibial band and biceps

This operation, described by Young, is specially suitable for those where the quadriceps paralysis is combined with flexion of the hip and knee.

A long incision from the great trochanter to the tuberosity of the tibia is required. The biceps is freed throughout its extent and is freed from its insertion. The insertion of the ilio tibial band is freed from the insertion into the tuberosity of the tibia. These two tendons are included in a tube made from the fascia lata, and the lower end of the ilio tibial band having been split is inserted into two holes drilled in the patella.

The hip contraction if present, is corrected four weeks after the operation and the knee contracture after that. At the end of the fifth week massage and muscle re education are begun.

Tendon Transplantation in the Hip Region

Transplantations in this area are limited to cases of paralysis of the gluteus medius and maximus. The operations are usually effective resulting in considerable improvement in the gait. Some surgeons attribute this improvement to prolonged rest rather than to the effect of transplantation.

(1) Paralysis of the Gluteus Maximus In paralysis of this muscle the body is thrown back with a sudden lurch when the patient's weight is borne on the affected side and the patient quickly brings the other leg forward to bear his weight. The gait is like that of a patient wearing an artificial leg. Two operations have been performed for the condition.

(a) Ober's Operation An incision is made from the level of the first lumbar vertebra 1 inch (2.5 cm) lateral to the spine to the posterior inferior spine of the ilium exposing the fascia over the muscles in this region. The fascia is incised longitudinally near the spinous processes and cleared from the muscles. The lateral half of the sacro spinalis with its aponeurosis is separated from the medial half and from the muscles lateral to it, the incisions being carried down to the lower end of the skin incision. This portion is then freed from the crest of the ilium from the sacrum and from the transverse processes in such a way that a free flap of muscle, about 5 inches long, 1 inch wide and $\frac{3}{4}$ inch thick is obtained. An incision is next made on the lateral aspect of the thigh from the tip of the greater trochanter to 1 inch above the level of the patella,

exposing the fascia lata and its tensor. The tensor is freed and parallel incisions made in the fascia to the level of the skin incision in order to form a long flap of fascia 1 inch wide. A hole is drilled through the femur at the level of the gluteus maximus tendon just below the neck and the long flap of fascia is drawn through the bone from before backwards. At that point the edges of the fascia are sutured to the gluteus maximus tendon. The free end of the fascial flap is then drawn up under the gluteal fascia to the lower end of the first incision care being taken to keep the gliding surface of the fascia next to the iliac bone. The superficial surface of the fascial flap is scarified and then overlapped for 2 or 3 inches by the free flap of the sacro spinalis. The edges of the fascial flap and the aponeurosis of the sacro spinalis muscle are then sutured together under moderate tension so that

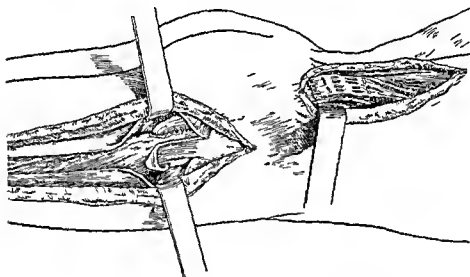


FIG. 236.—Obers's Operation. The active erector spinae muscle is used to take the place of the paralysed gluteus maximus by transplantation of a strip of fascia latae.

extension of the hip is obtained by the sacro spinalis muscle acting on the femur. A plaster cast is applied with the limb in abduction and full extension for a period of four to six weeks after which walking exercises may be permitted.

(12) *Dickson's Operation*. This is designed to replace the paralysed glutei muscles by the tensor fasciæ latae. The origin of the tensor fasciæ latae is transplanted with a piece of its bony attachment to a groove on the crest of the ilium near the posterior superior spine the muscle thus being changed from an abductor and flexor to an abductor and extensor. Dickson after a series of forty operations of this nature claims a considerable degree of success.

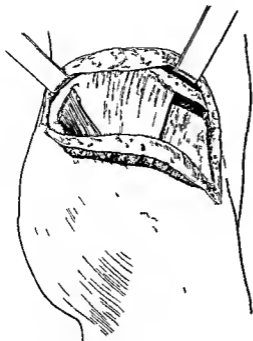


Fig. 237 —Dickson's Operation showing the Method of Transplantation

(2) **Paralysis of the Gluteus Medius Muscle** The gluteus medius is frequently affected in infantile paralysis. Its function is to abduct the limb and when the weight is borne on one side to raise the opposite side of the pelvis. When the muscle is paralysed the resulting gait is characteristic. When in walking the weight is borne by the affected side the patient lurches over to that side, with consequent upset of balance. The limp is often indistinguishable from that

produced by a short leg and it cannot be compensated for by any apparatus or by any building up of the sole of the boot. It can however be eliminated to a great extent if the patient carries a weight of about 12-14 lb in the hand of the affected side. This changes the centre of gravity and compensates for the weakness of the muscle.

Treatment by Legg's Operation The insertion of the tensor fasciae latae is transferred to the posterior surface of the femur. An incision is made from the anterior superior spine backwards and downwards over the greater trochanter to a point 3 inches below it. The fascia lata is thus exposed in the anterior part of the wound throughout the full extent of the incision. Along this line it is incised and from the lowest point a cross incision is made backwards for $1\frac{1}{2}$ inches. The posterior border of the tensor fascia is then defined, and the entire tendon mobilized. The lateral and posterior surface of the femur is then exposed $2\frac{1}{2}$ inches below the trochanter by dividing the fibres of the vastus lateralis. At this point a periosteal flap is turned down from the bone and a groove made. Into this groove the free end of the fascia lata bearing the tensor is sutured and the periosteal flap replaced and closed over the groove, the thigh being fixed at 30 degrees abduction. The hip is thereafter retained in a plaster of Paris spica in 30 degrees abduction for about two months. An abduction splint is worn for about six months.

The operations should not be performed when there is in addition, marked involvement of the gluteus maximus.

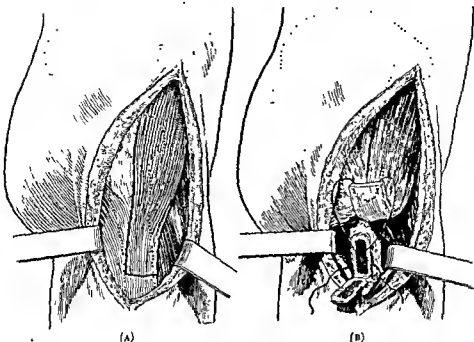


FIG. 238.—Legg's Operation for Gluteal Paralysis. (A) The line of division of the tensor fascia lata. (B) The fixation of the tendon into the femur.

Operations to Improve Function in Paralysis of the Arm

1. Deltoid Paralysis.

In the majority of cases of deltoid paralysis, arthrodesis is the operation of choice. In early childhood, however, it is preferable to perform one of the two types of tendon transplantation.

(1) *Transplantation of the Trapezius into the Humerus.* A six-inch incision is made in the line of the deltoid and trapezius fibres, with its centre over the acromion. The acromion and the trapezius having been exposed, a slip of the acromion, with its attached band of trapezius fibres, is mobilized and freed into the neck. The upper end of the humerus is now exposed by an incision through the deltoid. A sub-periosteal flap is taken from the humerus and the piece of acromion is embedded in the resulting groove after the arm has been fully abducted, or even brought up into the vertical position. After the wound is closed, this position is retained by a plaster casing.

It is sometimes difficult to approximate the trapezius to the humerus. To overcome this difficulty, Meyer uses strips of fascia to lengthen the trapezius. Occasionally the trapezius may slip in front of, or behind, the remainder of the acromion, and so lose its fulcrum. The length of the lever obtained by transplanting the trapezius is very short for the abduction of the humerus, but good results have been recorded.

(2) *Transplantation of the Biceps and Triceps into the Acromion.* F. R. Ober has devised and practised another transplant operation

which has had a good result in one case. In this the tendons of both biceps and triceps are utilized to produce abduction of the arm. An incision is made across the top of the shoulder exposing the acromion process down the front of the arm exposing the coracoid process and the short head of the biceps and down the back of the shoulder exposing the long head of the triceps. The short head of the biceps is isolated and the tip of the coracoid process cut off. The long head of the triceps is isolated and the bone from which it arises is chipped off. The acromion is split on the flat. The biceps tendon is sewn into the front of the acromion the triceps tendon into the back of the same bone using stout silk sutures for the purpose. In the case described a girl of 7 who had had poliomyelitis with deltoid paralysis was able after the operation to abduct the arm fully and to raise it to the side of the head.

(3) *Arthrodesis of the Shoulder*. This choice is last since it has disadvantages—movements are limited fractures occur easily owing to its exposed position and the decalcification secondary to the paralysis the cosmetic effect—particularly in a female—is not appreciated by the patient it is unsuccessful under the age of 12 and it may lead to a scoliosis. Under these circumstances where muscles are available transplantation should be attempted but if the result is disappointing then arthrodesis may still be done. Usually there is an adequate number of healthy muscles acting upon the shoulder girdle to enable the arm to perform all remaining possible movements if the shoulder joint is obliterated. The shoulder girdle should be very carefully examined previous to operation in order to make sure that the principal muscles which rotate the shoulder blade are not affected as this free mobility depends on scapular rotation. In addition to this there must be no scars in the region which would immobilize the scapula. The trapezius and the serratus anterior are important muscles as they rotate the shoulder blade into the position of abduction with both muscles acting satisfactorily there should be good mobility of the shoulder and therefore a good functional result.

The operation is described in Chapter XIX.

2 Paralysis of the Serratus Anterior

When this muscle is paralysed there is loss of the power of pushing forwards. Riedel has reported a method of transplantation of the latissimus dorsi which he has employed with good results. An incision is made extending from the spinal column to the axillary border of the scapula the latissimus dorsi muscle being exposed. The lower half of the muscle is separated from the upper its tendinous insertion divided passed under the upper portion of the muscle and after passing over the lower angle of the scapula is fixed to the seventh and eighth ribs. In this way the transplanted muscle is made to act as a muscular ligament for the support of the scapula and prevent it from sliding off the trunk. It is doubtful if the operation fulfils the

results claimed for it. Strips of fascia lata may be used with better effect. These strips are fixed to the seventh and eighth ribs passed behind the scapula then forwards deep to the scapula and finally fixed to its axillary border. This attaches the scapula effectively to the trunk and allows pushing movements of adequate strength to be carried out.

3 Paralysis of the Flexors of the Elbow

Where the joint is flail an arthrodesis gives of course the best and strongest result but if the paralysis is incomplete then some form of transplantation may be tried. When there is paralysis of all the primary flexors of the elbow i.e. the biceps brachialis and brachio radialis and when the flexors of the wrist and fingers are intact Steindler's operation of transposition of the common flexor origin from the medial epicondyle to a higher level may be carried out. An incision is made on the medial side of the humerus extending to 3 inches above the medial epicondyle. The ulnar nerve is identified behind the epicondyle and retracted. The origin of the flexor muscles of the forearm at the epicondyle having been carefully defined the muscles are detached from the bone close to the periosteum in one mass. These muscles are the superficial head of the pronator teres the flexor carpi radialis the palmaris longus and the flexor carpi ulnaris. They are mobilized downwards for a distance of $1\frac{1}{2}$ inches from the epicondyle until the mass is sufficiently free to be transplanted into the intermuscular septum or into the periosteum of the humerus about 2 inches above the condyle. They are secured in position by strong sutures which fasten the muscles to the septum. The arm acutely flexed is immobilized in plaster for about four weeks after which a splint is substituted and worn for at least two months.

After treatment begins with the removal of the cast and consists of active and passive movement and muscle training.

4 Tendon Transplantation in the Wrist and Finger

Some of the most successful tendon transplantations are done for paralysis of the muscles of the forearm especially the extensor group. The operation described in the chapter on Injuries of the Peripheral Nerves may be modified to suit the types of paralysis met with in poliomyelitis. It is to be noted however that the extensors do not act well when transplanted into the flexors of the forearm.

Operations to Increase the Stability of a Flail Joint

1 Arthrodesis This term is used to denote the operation of excision of a joint by removal of the articular cartilages with the object of producing ankylosis. In the lower extremity the operation has the disadvantage of leaving a certain amount of shortening. It is contra indicated in patients under 8 years of age as it is apt to interfere with

epiphyseal growth It is not an operation to be undertaken lightly as it produces a permanently stiff joint, but in certain cases it is definitely indicated

(a) *The Shoulder* The operation of arthrodesis of the shoulder is described in Chapter XIX The necessity of good scapular movement and a useful hand must be remembered If these conditions are not fulfilled the function of the limb will not be improved

(b) *The Elbow* The elbow can be efficiently controlled by an apparatus Arthrodesis, therefore, is seldom practised at this joint

(c) *The Wrist* The wrist can usually be made to function by some form of tendon transplantum An arthrodesis is occasionally carried out after the method described on page 359

(d) *The Hip* The operation of arthrodesis of the hip is sometimes unsuccessful because the bones are not thoroughly ossified An ischial bearing corset is often of more value and permits good movement at the hip joint The operation usually performed is a modification of the intra articular method described by Albee

THE TECHNIQUE The hip joint is approached by the method of Smith Petersen and the capsule defined and incised, with the head of the femur *in situ* About one third of the upper hemisphere of the head is then removed with a long osteotome in a plane parallel to the axis of the neck The roof of the acetabulum having been similarly denuded its raw flat surface is placed in apposition to the upper surface of the head The whole of the articular cartilage is then removed from the remains of the head and the acetabulum, and small chips recovered from the removed portion are wedged between the bones A tri fin nail may now be inserted to ensure adequate immobilization The pelvis and the affected leg are then immobilized in a plaster spica for about three months

(e) *The Knee* Growth in stature takes place chiefly at this joint A permanently stiff knee has definite disadvantages Further, the joint can be easily controlled by a well fitting brace For these reasons arthrodesis of the knee is undertaken only in exceptional cases If the operation is indicated it should be carried out in the manner described on page 341

Stabilizing, or Arthrodesing, Operations on the Foot

Various stabilizing operations are carried out with great success on the foot It has already been suggested that tendon transplantation is frequently unsatisfactory unless it is combined with one or other of certain supplementary operations in which case greatly improved function is frequently achieved These supplementary operations are not carried out before the age of 12 Moreover it is of great importance before undertaking an operation on a deformed or flail ankle, to make sure that the neighbouring weight-bearing joints—the hip

and the knee—are in a position to co operate The only justification for these operations is a reasonable certainty of definite functional gain

Lambrinudi's Operation The special indications for this operation according to Fitzgerald and Seddon are paralysis of the foot dorsal flexors and peronei but with some muscular control of the knee and preferably with active calf muscles It is better to wait till the child is over the age of 12 The aim of the operation is to use the anterior process of the talus to prevent dropping of the foot The plane of bone section is carefully planned before the operation

The tarsus is approached through a lateral incision and the foot is dislocated medially below the talus The talus is then cut by a saw in the desired plane as shown in the line drawing The upper surface of the calcaneus and the calcaneo cuboid joint are cut with a sharp

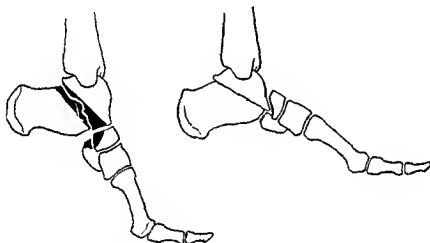


FIG 39—Lambrinudi's Operation for Drop Foot

osteotome A notch is also cut in the navicular The bones are now apposed and the beak in the talus fitted into the notch in the navicular and held in place while the incision is closed and a leg plaster applied The foot and leg are of course elevated after the operation and in two weeks the plaster is removed and a new closely fitting one applied for five months

Whitman's Astragalectomy This operation is indicated in pes calcaneus calcaneo varus calcaneo vulgus and calcaneo cavus It may also be used in cases of congenital club foot as well as in united fracture of the talus

TECHNIQUE The incision starts about 1 inch above and behind the lateral malleolus passes downwards and round the lower end of

the fibula forwards $\frac{1}{2}$ inch below the malleolus and then in a curve over the dorsum of the foot to the head of the talus. The peroneal sheaths having been opened the tendons are divided and reflected and the external lateral and the interosseous ligaments divided. Commencing at the body and proceeding to the neck and head the talus is now dissected out from beneath the extensor tendons. Thereafter the foot is forcibly inverted so that the whole ankle joint is opened up. The head and neck of the talus may now be freed until the entire bone is completely separated from its ligamentous attachments and can be removed. The internal surfaces of both malleoli are then denuded of cartilage and a new site of articulation made for them nearer the front of the foot. To do this a thin section of bone is cut from the lateral aspect of the calcaneo cuboid joint and the soft tissues, along

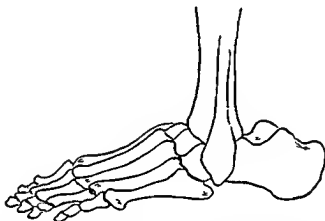


FIG. 40.—Infantile Paralysis. Whitman's Astragalectomy.

The foot is displaced backwards on the leg bones, so that the weight is borne on the dome of the arch of the foot.

with a thin section of bone stripped off the medial surface of the navicular. The foot is now displaced backwards for at least 1 inch and the inner surfaces of the malleoli adapted to the junction of the calcaneus and the cuboid on the lateral side and to a point directly behind the navicular on the medial side of the foot. The anterior surface of the tibia now lies in the same plane as the mid tarsal joint the backward protrusion of the heel being exaggerated. The wound is closed after reuniting the peroneal tendons. The foot is retained in a position of plantar flexion and slight valgus by a plaster of Paris splint which reaches to a point above the flexed knee. The knee is suspended from a cage for the first two or three days to prevent the onset of œdema. It is kept in plaster for about three months. During that time the case may be changed to verify and correct if necessary the position of the foot. After removal of the plaster, the patient

should be able to wear an ordinary boot which may require padding over the prominent heel.

The Stabilizing Operation of Hoke This is practised in similar types of feet to those on which the Whitman operation is performed but is especially useful for valgus deformity. It is an elaboration of the Whitman method in that there is an arthrodesis of the sub taloid and the talo navicular joints as well as backward displacement of the foot.

THE TECHNIQUE The incision is similar to that used in Whitman's operation. The peronei are divided, the sinus tarsi is cleared of its adipose tissue and the head, neck and adjacent portion of the body of the talus are stripped. The sub taloid joint is then carefully dissected so that the superior surface of the calcaneus and the lower surface of the talus are laid bare. The head of the talus is next separated from the navicular by division of the ligaments. A broad osteotome is now used to remove the adjacent portions of the lower surface

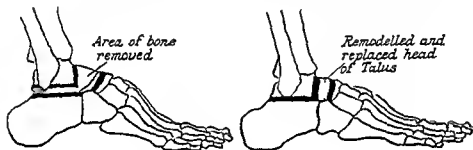


FIG. 241.—Hoke's Operation for Paralytic Feet

of the talus and the upper surface of the calcaneus the incision traversing the entire width of the bone. The talus is now remodelled. The bone is first cut through at its neck and the head and neck removed. The articular surface of the navicular as well as that of the talus is peeled off. With the head and neck thus removed any deformity of the posterior part of the foot can be corrected by setting the calcaneus in line with the axis of the leg so that any lateral rotation of the calcaneus is corrected. The heel can now be displaced backwards so that the weight bearing centre is placed exactly as in Whitman's excision of the talus. The excised fragment of talus is then shaped to fit into the space left between the body of the talus and the navicular and reinserted there.

The after treatment is the same as in Whitman's operation but usually occupies less time seven weeks in plaster of Paris being as a rule sufficient. This operation is superior to that of Whitman in that it produces less shortening of the leg. The backward displacement of the foot however is possible only to a less degree.

The Naughton Dunn Operation In those deformities of the foot in which because of severe static deficiencies it is desirable to secure forward displacement of the talus on the calcaneus the operation of Naughton Dunn is indicated. This operation combines with a sub taloid arthrodesis a reconstructive shortening of the fore foot. A degree of symmetry between the two halves of the longitudinal arch is thus established, so that the static condition of the foot is improved.

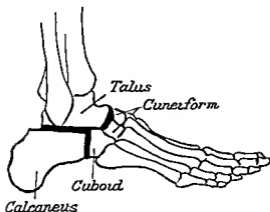


FIG. 24°—Naughton Dunn's Operation for stabilization of the flat foot

TECHNIQUE A lateral semilunar incision is made extending from above and behind the lateral malleolus and curving below

the prominence and forwards over the dorsum of the foot to the third metatarsal bone. After reflexion of the flap the origin of the extensor digitorum brevis is detached from the dorsal aspect of the calcaneus and reflected with the soft structures to the medial side so exposing the tarsal bones. The calcaneo cuboid joint is now exposed by retracting or dividing the peroneal tendons. It may be necessary at this point to elongate the tendo calcaneus. The articular surfaces of the calcaneus and cuboid are now removed by means of a sharp osteotome. The amount of bone removed depends upon the deformity to be corrected. The head of the talus is now divided behind its articular cartilage, and this, along with the proximal surfaces of the cuneiform bones is removed together with the whole, or a portion of the navicular. The strong interosseous ligament between the talus and the calcaneus and the lateral ligaments of the ankle are divided and the foot dislocated medially at the sub taloid and mid tarsal joints. This exposes the sub taloid joint the cartilaginous opposing surfaces of which are removed by an osteotome.

Naughton Dunn points out that the foot is now in three sections and that the removal of bone will allow correction of the deformity. The foot is displaced backwards at the sub taloid joint so that the head of the talus will rest in a cup shaped depression prepared for it by the removal of bone from the dorsal surface of the cuneiform bones. In some cases a transplantation of tendons or a tenodesis is now carried out. The extensor digitorum brevis is replaced and fixed by catgut stitches and the peroneal tendons sutured if previously divided. With the foot held in a good weight bearing position and with the raw bone surfaces adequately apposed the whole is fixed in plaster of Paris. The position of fixation of the foot is of great im-

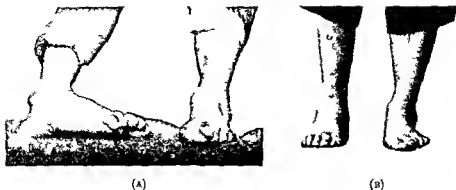


FIG. 43. Infantile Paralysis. (A) Talipes equinovarus with callosities on the lateral surface where weight is borne. (B) The result of a Vinckler-Dunn operation in the same case.

portance. The talus and calcaneus are directly centred under the bones of the leg. The relation of the forepart of the foot to the posterior segment allows restoration of the normal arch and weight bearing with both the first and fifth metatarsal heads.

The dressings applied should not be very thick so that during the moulding and setting of the plaster the malleoli may be palpated. The patella should be exposed to ensure correct alignment. The leg is elevated by suspending it from a bed cage for the first few days to prevent the onset of oedema. Ten days after operation the stitches are removed and the position of the foot verified and the plaster reapplied. Walking in plaster is allowed one month after the operation and this form of fixation is continued for six months.

Pan taloid Arthrodesis. This type of operation is used by Steindler for cases of drop and drop dangle foot. A flail foot not deformed associated with a good knee or at least good or fair flexors is best suited for this method. A curved incision is made beginning 2 inches above and behind the lateral malleolus curving downwards and forwards around its tip to a point 2 inches in front of it. The peroneal tendons are divided as well as the calcaneo fibular ligament and the joint opened by wrenching the foot into adduction. The joint surfaces of the tibia and fibula and the upper surface of the talus are now denuded of cartilage until nothing but raw cancellous bone is seen. The talo calcanean joint can now be exposed by dividing the ligaments and is also denuded of its cartilage. After division of the talo navicular ligaments the joint between these two bones is opened and denuded of its cartilage. The calcaneo cuboid joint

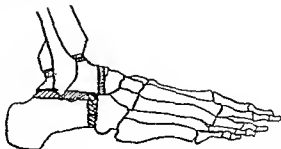


FIG. 44.—Pan taloid Arthrodesis.

may in some cases be excised. When the denudation of cartilage is completed in all joints the talus is replaced and the foot is put up again in its normal position. The cut ends of the peronei are reunited, the wound closed in layers and the foot put up in plaster. The best position is that of perfect lateral alignment, with about 20 degrees of drop corresponding to about 1 inch of plantar flexion. The plaster should remain in place for about four months after which it is replaced by an ordinary strong boot.

Extra-articular Check Operations on the Ankle

This type of operation differs from the extra articular arthrodesis practised in tuberculous conditions in that the movement of the joint is not completely obliterated but is merely diminished by the construction of artificial bony blocks.

Campbell's Operation for Drop Foot This is done in cases of paralytic drop foot and is usually combined with a sub taloid arthrodesis.

TECHNIQUE An incision is made over the antero lateral surface of the ankle from a point 1 inch above the joint and over the dorsum of the foot to the lateral cuneiform. The bones are exposed by reflecting the tendons medially and laterally, good access being gained thus to the entire tarsal region. A small portion of the head of the talus, the whole of the navicular, and the articular cartilages from the posterior surfaces of the cuneiform are resected. A second incision is now made over the tendo calcaneus which is divided into anterior and posterior flaps. These are retracted upwards and downwards. The space between the tendon and the tibia is now freed from loose tissue and with a large periosteal elevator the posterior surface of the tibia and the upper surface of the calcaneus are cleared. The foot is now dorsiflexed and the posterior edge of the body of the talus removed. A wedge shaped cavity is now chiselled out of the cal-

caneus, just below the posterior extremity of the talus, and into this cavity the denuded navicular and the small pieces of bone obtained in the first part of the operation are placed and piled into a pyramidal mass which rises well above the posterior edge of the tibia. The tendo calcaneus is united and the wound closed. The foot is now immobilized at a right angle or in slight plantar flexion in

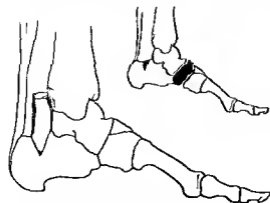


FIG. 245—Infantile Paralysis. Campbell's wedge block stabilizing Operation for Drop Foot.

a plaster of Paris cast and remains in this for at least three months. At the end of that time a strong boot with a lengthened upper should be worn.

Putti's Operation. This operation is carried out for paralytic calcaneal deformity, the object being to create a bony block at the anterior aspect of the talus, which will operate against undue dorsiflexion of the foot.

TECHNIQUE A vertical incision is made in front of the ankle joint and the extensors reflected so that the lower end of the tibia and the anterior surface of the body of the talus are exposed. The talus is now divided transversely with a chisel, about the middle of the body, and the upper portion is elevated by prising it backwards. This leaves a transverse gap in the body which is filled up by a thin layer of bone removed from the anterior aspect of the tibia. The anterior part of the body of the talus is thus built up and remains elevated. It then acts as a ridge, preventing any dorsiflexion of the foot. The wound is closed and the foot is fixed in slight plantar flexion for from three to four months. This procedure is carried out only in patients who are too young for a Naughton Dunn operation. It has the great advantage of simplicity.

Fixation by Silk Ligaments or Sutures

This operation was suggested by Lange many years ago, and has been performed frequently with varying degrees of success. It has recently been used in cases of congenital talipes equino varus, a silk ligament stretching from the base of the fifth metatarsal to the shaft of the tibia at a suitable level. The method, however, is not now used to any great extent, and the author does not recommend it.

Tendon Fixation

This type of operation is very useful in cases of drop foot. The tendons used for slinging the foot are the paralysed ones, their post-operative value being merely that of ligaments.

(1) Tenodesis for Drop Foot

TECHNIQUE An incision down to the level of the ankle joint is made over the tibialis anterior at its tendomuscular junction, and the tendon

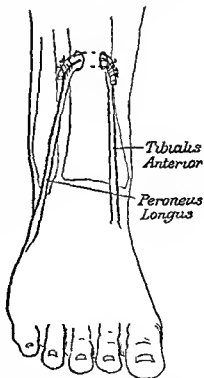


FIG. 246—Paralysis of the Foot Extensors. Operation of tendon fixation.

The peroneus longus is transposed in front of the lateral malleolus and along with the tibialis anterior slings the foot up to the front of the tibia.

divided and freed at its junction with the muscle fibres. The medial lip of the incision is reflected towards the medial side to expose the lower part of the tibia. Two further incisions are now made one over the peroneus longus tendon at its junction with the muscle belly the second just below the lateral malleolus towards the insertion of

the tendon. The tendon is divided at its insertion into the muscle belly and freed as far as the lower incision out of which the tendon is pulled. A subcutaneous tunnel is then constructed from the lower peroneal incision to the front of the tibia and the peroneal tendon brought up through it. The two peroneal incisions may now be closed. The next step is to drill a hole through the shaft of the tibia from lateral to medial side through which the tendons may be pulled. The tibialis anterior tendon is pulled from the medial side the peroneal tendon from the lateral side both traversing the same aperture in the tibia. The foot having been placed at a right angle the tendons are pulled taut and fixed by means of chromic catgut. The anterior tibial incision is now closed. The foot is fixed in a plaster of Paris case for about two months and if the anchorage of the tendons has been secure the result should be very satisfactory.

(2) *Gallie's Operation for Drop Foot*

Gallie has suggested a more complicated method which has advantages. He uses the lateral half of the tendon of the tibialis anterior cuts it at its insertion into its muscle belly and then threads it up through a bony tunnel made in the navicular and talus and then through another in front of the tibia (see Fig 247) and fixes it to the front of the tibia.

(3) *Gallie's Operation for Talipes*

Calcaneus. A straight vertical incision

is made along one side of the tendo calcaneus and the tendon retracted to expose the lower end of the posterior aspect of the tibia. A rectangular section of bone is raised from this surface by means of a sharp osteotome. It is of sufficient width to allow the tendo cal

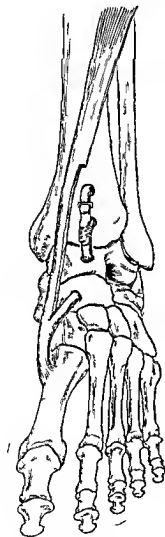


FIG 247—Gallie's Operation for Drop Foot

canus to be placed into it. The piece of bone is thereafter reinserted and fixed to retain the tendon in position, the foot deformity having been corrected before insertion.

The author now uses an operation devised on the lines of the tenodesis for drop foot. The tendo-calcaneus is exposed as above and long narrow slips are isolated from the tendon on either side. These are divided high up, so leaving a medial and lateral slip attached to the calcaneus below. After a tunnel is drilled laterally in the tibia at an appropriate level the tendons are threaded through it and fixed as in the operation for drop foot (Fig. 248).

Lengthening of the Limb

Since one of the end-results of a severe attack of infantile paralysis is a disturbance of trophic function, there is frequently left a shortening of 2 or 3 inches in an affected limb; this adds considerably to any interference with function which is already present. Putti has described an operation by which he has actually lengthened a bone on the short side, the lengthening being done preferably on the femur as the soft parts above the knee are more extensible than those below. He secures continuous traction by means of an ingenious apparatus called the osteoton, consisting of two large metal pins penetrating the upper and lower fragments of the fracture and a telescopic tube fitted with a spring which is governed by a screw.

Technique of the Operation. See Chapter XVI.

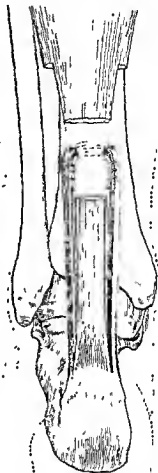


FIG. 248.—Author's Operation for Talipes Calcaneus.

SPASTIC PARALYSIS

Spastic paralysis has an importance second only to infantile paralysis in orthopaedic surgery. It is a lesion of the upper neurone in which, as a result of loss of cerebral inhibition, the tone of the muscles is greatly increased, the reflexes are exaggerated, and a general state of

hypertonus develops in the affected parts. Characterized by muscular weakness, stiffness and loss of control rather than by definite paralysis it usually leads to atrophy, contraction and deformity. Involvement of one half of the body is known as hemiplegia of both lower extremities as paraplegia. When both upper and lower extremities are affected a diplegia results. In the rare event of involvement of only one extremity the condition is termed monoplegia. In severe cases the trunk and face may be affected.

ETIOLOGY

The paralysis is due to the destruction of the ganglion cells of the motor area by disease of or injury to the brain. The disease may be ante natal in origin but more often dates from the time of the birth which is usually a difficult one and often carried out with the aid of forceps. First-born children are affected more frequently than others and there is often a history of premature birth. As the pyramidal motor tract is not fully developed until the eighth month it is not unusual to get developmental defects in babies born before that period. In rarer cases the disease arises after birth and may be a sequel to one of the exanthemata.

Jones and Lovett classify the cases in this way

- | | |
|--------------------|---|
| 1 Ante natal Cases | Developmental defects Syphilis |
| 2 Natal | Trauma during labour |
| 3 Post natal | Circulatory conditions hæmorrhage etc. In inflammatory conditions—meningitis hydro cephalus |

Crothers states that many cases hitherto regarded as having their origin in the cerebrum are really due to injuries of the spinal cord and has called attention to the dangers of traction on the child during labour.

Collier maintains that the damage is done before birth attributing the lesion to primary neuronic degeneration. If this is so it explains why the operation of cerebral decompression fails to bring relief.

PATHOLOGY

Cerebral hæmorrhage is said to occur in 15 per cent of the new born but severe bleeding is uncommon. The hæmorrhage is followed by atrophy of the brain with sclerosis and shrinkage of the convolutions or by softening and degeneration of certain areas. The brain cortex is often smooth. The arachnoid is thickened and sub arachnoid cysts are present but the dura is usually normal. There is degeneration of the pyramidal tracts and of the lateral columns of the cord. Microscopically there is an absence of ganglion cells and nerve fibres in the atrophied area their place being occupied by areas of gliosis.



(a)



(b)

FIG. 749—Spastic Paralysis

(a) The voluntary attempt to correct the flexion deformity of the hand and fingers, (b) The appearance of the hand when the wrist drop is passively corrected

CLINICAL FEATURES

There is frequently a history of difficult birth, followed by cyanosis, but the first sign of any serious disturbance may be a convulsion indicating the cerebral origin of the disease. These post-natal cases often commence suddenly during the course of some infectious disease. The mother notices the child's difficulty in controlling the movements of the extremities. All movements are imperfectly carried out, and there is slowness in sitting up, standing and walking.

The Paralysis This is of the upper neurone, or spastic type, and is characterized by the hypertonic condition of the affected muscles and the exaggerated reflexes. There is no wasting or reaction of degeneration of the muscles. Muscular rigidity is marked, and leads, in the lower limbs to adductor spasm when the child begins to walk. Any attempt to straighten the limbs is resisted by contraction of the muscles. These, however, can be stretched gradually, and the limb thus slowly straightened out, but as soon as pressure is released the spasm returns.

Walking is usually considerably delayed, and is performed with a characteristic inco-ordinated gait. The method by which certain movements are performed is also very characteristic, in that, when a special muscle of the hand or foot is being used, all the other muscles of that limb become spastic and contracted. The child apparently cannot use one set of muscles without the others being stimulated to contract. As the child grows older, and the flexion contracture at the various joints persists, the normal muscles become weakened by stretching and the deformity becomes a fixed one. In the lower limbs, the hips are flexed, adducted and rotated medially, the knees are flexed, and the feet are usually in a position of equino varus. The deformity of the upper limb is equally characteristic. There is flexion at the elbow, the forearm is pronated, the wrist is flexed, and the thumb adducted and pressed into the palm in that position by the flexed fingers. All the tendon reflexes are exaggerated. Facial paralysis occurs frequently but disturbances of sensation are rare.

Involuntary Movements Curious involuntary movements may develop and interfere greatly with the function of the limb. They may appear soon after birth, in the form of rhythmical athetoid movements, of the more explosive and erratic choréic type or may belong to the 'perverse movement' group. These are limited to the affected limb and are usually more troublesome in the arms than in the legs. In addition to reducing the patient to a pitiable state and adding considerably to the gravity of the disease, they constitute, according to some authorities, a definite contra-indication to operative interference. The movements are exaggerated by voluntary efforts and by emotion, but are usually absent during sleep. Their presence and the inco-ordination of gait are attributed to changes in the basal ganglia.

Mental Symptoms Mental deficiency varies with the severity of the limb affections, but is present in all grades. At the best the child is emotionally unstable, and this is doubtless exaggerated by the limitation of normal activities imposed by the affection. Cameron and Osman state that most patients improve greatly both mentally and physically as they grow older. There is little doubt too that an operation attended with any degree of local success at the same time improves the mental condition. The child is enabled to get about and mix with other children so that his outlook is broadened. In addition he is freed from the necessity of worrying about his gait and can attend to other things.

Sachs states that 50 per cent of hemiplegic cases are feeble minded and 13 per cent idiotic.

Epileptic seizures are more commonly associated with hemiplegia than with other forms of spastic paralysis. If the fits recur with any frequency operative treatment should be delayed.

Trophic Changes There is usually some impairment in growth of the affected limb. It develops more slowly than the healthy one and in adult life there is usually a considerable disparity in the lengths of the two limbs.

The Deformity Deformities are the result of spasm of the stronger groups of muscles or of those muscles which act at a mechanical advantage. In some cases gravity is a contributory factor. It is important to remember that as deformity can be produced by fixing the limb in a particular position for a sufficient time all the muscles are potential sources of deformity in an ordinary case. This is of particular importance in post operative treatment.

At first the deformities can be fully corrected by strong manual pressure but secondary contractures develop at a later date so that manual correction of the deformity can be only partial. The time which this secondary contracture takes to develop varies from a few months to as long as three years. It is accompanied of course by accommodative changes in the ligaments, fasciæ and other soft tissues.



11. 250—Spastic Paralysis
The typical gait and expression of a case of moderate degree

DIFFERENTIAL DIAGNOSIS

Poliomyelitis A form of spastic paralysis may occur as a result of infantile paralysis affecting the cerebral tissues. It is an upper neurone lesion which occurs in association with a flaccid paralysis so that there is presumptive evidence of the poliomyelitic origin of the condition.



FIG. 251 Typical Cerebral Spastic Paraplegia

Idiocy When idiocy is present with spastic paralysis it may be assumed that the case belongs to the spastic paralytic type.

Cerebral Tumour is distinguished by its localizing symptoms, headache, vomiting and eye signs.

Hydrocephalus may cause spastic paralysis of some muscles but the diagnosis is usually obvious.

PROGNOSIS

Without treatment the prognosis is very poor although in some cases intelligence may improve and better control be acquired. In the very mild cases treatment should give a good result and even in cases of a more severe degree improvement is to be expected. Athetosis, mental enfeeblement and extreme paralysis are of ill omen in prognosis.

An outdoor life as far as possible free from care is to be recommended. Worry or indeed excitement of any kind should be avoided.

TREATMENT

The treatment of the condition is classified as non-operative and operative.

(a) NON-OPERATIVE TREATMENT

Massage as commonly prescribed for such patients is worse than useless as it increases the tone of the already hypertonic muscles. It is to be used only in cases in which after operation muscles weakened by previous stretching would benefit from massage. It is to be noted that these muscles are not the spastic muscles but their opposing groups.

Muscle Re-education is the most important part of the non-operative treatment. The patient is taught to use the weaker muscles, e g in the arms, the extensors, the lateral rotators, and the supinators. The hand is assisted by passive movement until the maximum of normal voluntary movement is reached, and then gently stretched before the limb is passively replaced in the flexed position. This cycle is repeated frequently, and often the power and range are considerably increased. The patient is taught to perform coarser movements of the limb, e g the shoulder movements, before the finer movements of the fingers are approached.

Rhythmical movements such as drill are valuable. Movements may be performed to the accompaniment of a metronome or music. It is also very desirable to stretch the contracted muscles continuously by splints. When the lower extremity is affected, good results may be obtained at a late stage by fixing the limb in a plaster case with the leg fully abducted. This is removed at the end of two or three months, after which braces may be worn to keep the leg extended and abduction splints applied to prevent adduction of the hip. These are ambulatory splints, and allow systematic exercises to be carried out every day.

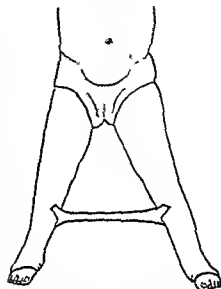


FIG 202—Spastic Paralysis Plaster applied in a case of adduction deformity

The non operative form of treatment is certainly the more important. Operation can only prevent deformity and prepare to some extent the way for the non operative treatment by diminishing the muscular spasm.

(b) OPERATIVE TREATMENT

It is not wise to carry out operations on children under the age of 5 or 6, as they are unable to co operate or to obey the instructions which are so essential in the after treatment. Mental enfeeblement, athetoid movements and epileptic seizures, to some extent, contraindicate operation, but if these affections are not too severe, an operation may greatly improve the mental condition and lessen the athetoid movements.

The operations that are carried out for the relief of spastic paralysis may be divided into two groups

- 1 Operations on the Nervous System
- 2 Operations on Muscles and Tendons

1 Operations on the Nervous System

A Operations on the Cerebrum At one time cerebral decompression was recommended in newly born children with paralysis as it was thought to be a reasonable procedure should any meningeal or cortical hæmorrhage have occurred. The results of this operation have not been good, however and this is not surprising if Collier is correct in believing that the condition is a primary neuronie degeneration present before birth.

Clem has recently treated babies of from 1 to 34 months by repeated cisternal puncture. He removes from 10 to 70 c.c. of fluid and has noted the greatest relief in spasms with a history of birth injury. The indications for the repeated drainage are listlessness, poor appetite, loss of weight and increased spasticity. The drainages are followed by a dry or semi-dry diet with elimination of sugar and salt.

B Operations on the Peripheral Nerves

(a) *Foerster's Operation* *Division of the Posterior Spinal Roots* (Posterior Rhizotomy) It was hoped that this operation consisting as it did of division of the afferent paths to the cord, would check the hyperactivity of the muscles and ensure better co-ordination of the limb. The operation is a difficult one and in view of its disappointing results has been for the most part abandoned. Posterior rhizotomy is thought to weaken all groups alike and to diminish voluntary control no less than reflex spasticity. It is therefore not described in detail.

(b) *Section of the Extra pyramidal Tract* Putnam has sectioned the extra pyramidal motor tract in five cases for athetosis and dystonia. Four of the cases showed a definite improvement in the uncontrolled muscular activity and there were no ill effects from the operation.

(c) *Sympathetic Ramisection* Hunter believed that muscle tone was largely under the influence of the sympathetic system and that the operation of sympathetic ramisection, designed by Royle and himself would reduce spasm and leave the voluntary control of the muscles intact. This procedure has not been so successful as was at first hoped and in fact has been condemned in no uncertain terms by competent workers in this country after a series of patients had been submitted to operation in their presence by Royle. Nevertheless the operation is still practised both in this country and America apparently with success—particularly in lower limb lesions but the benefit would appear to be in the general nutrition of the limb rather than in the spasticity. The author does not practise the operation in spastic paralysis.

(d) *Stoffel's Operation* This relaxes the spasm in a certain number of muscle fibres in each muscle by cutting out part of its nerve supply. By studying the intra neural topography of the large nerve trunks, Stoffel demonstrated that the various tracts run independently for a considerable distance and that the position of any bundle in a large

nerve at a given level is remarkably constant. He was therefore able to pick out the nerve supply to any required muscle group and destroy as much or as little as he considered necessary in each individual case. The operation of Stoffel, however, is not now used in its original form. Surgeons prefer to follow the nerve down till its individual branches can be traced from the parent nerve into the muscles they supply. It is then easy to resect a number of the fibres going to any particular muscle, and in this form Stoffel's operation has become firmly established. The effect is lasting and there is no tendency to recurrence. The obvious objection is that if too much is done in the way of division of nerve fibres the harm cannot be undone. Fortunately the tendency is to err on the safe side.

2. Operations on Muscles and Tendons

The operations on muscles and tendons include tenotomy and myotomy, tendon lengthening, excision of portions of tendons and muscles, and transplantations. Simple tenotomies and myotomies are the oldest method of treatment and are of great value, particularly when done by open operation. Subcutaneous tenotomies may be performed in the adductor region for an adduction contracture of the hip, but in the case of all other muscles open division is advisable. In certain cases of flexion contraction at the knee, the hamstring tendons may be brought forward and transplanted into the quadriceps to strengthen the weaker extensor group.

THE TREATMENT OF DEFORMITIES IN VARIOUS REGIONS

1. Deformity of the Arm

The operation devised by Stoffel is very useful in this condition, but here again the nerve section is that of branches and not of parts of the main nerve. The motor branches are exposed in the forearm, identified by an electrode, and divided in whole or in part according to the severity of the contracture.

The Operation. It is not usually necessary to deal with the contracture at the elbow, and attention is mainly directed to the contracture at the wrist and fingers. The median nerve is exposed in the upper part of the forearm through a median incision and the various branches identified. The proximal branch is that to the superficial head of the pronator radii teres, which leaves the nerve from its anterior aspect. Thereafter branches leave to supply the flexor carpi radialis, palmaris longus, and the deep head of the pronator radii teres. More distally the branches to the flexors of the fingers leave from the dorsal and ulnar aspects. The various branches are identified accurately by a needle electrode and divided in whole or in part according to the results of the pre-operative examination.

After the operation the deformities should, as far as possible, be corrected and maintained so by splintage for some weeks

In some cases good functional results are got by arthrodesing the wrist after the manner advocated by Brittain

2 Deformities of the Hip Region

(a) **Adduction Deformity** Although improvement may be secured by operations on the muscles in this region, much better results are obtained by division of the nerves after the method of Stoffel. The obturator nerve may be approached either in the upper part of the thigh or through an abdominal incision, in the latter case, the nerves on both sides may be operated on at the same time. If the thigh approach is used both the anterior and posterior branches of the main nerve may be divided through one incision. The type of operation depends upon the extent of the spasticity. In severe cases the main trunk should be divided or, at any rate both its divisions, but where there is only a moderate degree of spasticity, division of the anterior branch suffices.

The Operation in Moderate Cases An incision, about 3 inches long is made from the pubic spine, downwards along the line of the tendon of the adductor longus. The tendon is identified and its inner margin having been dissected free without entering the muscle substance it is retracted outwards. This brings into view, in the intermuscular fascia behind it the anterior division of the obturator nerve. It supplies the gracilis, the adductor longus, and a portion of the adductor brevis. The main trunk of the anterior division has three branches which should be identified before any excision is performed. Half an inch of the anterior division is now excised. The various branches may be found entering their respective muscles.

The Operation in Severe Cases In these cases either the main trunk or both the anterior and posterior branches may be divided. For division of the branches, the operation described above may be carried a stage further until the posterior branch is seen and excised. This branch is found high up in the anterior wound, either issuing from the obturator foramen, or running behind the anterior fibres of the obturator externus and behind the adductor brevis. It is divided in a similar manner to the anterior.

Section of the Main Nerve A median supra pubic skin incision is made and the recti muscles separated. The bladder is carefully avoided and the pelvis inspected. The nerve can be seen as a white cord running along the side of the pelvis to disappear through the obturator foramen. It is in close relation to a number of veins which should be carefully separated from it before it is excised. Either a complete segment of the whole nerve, or a portion equal in diameter to four fifths of the cross section, is removed, the amount depending on the extent of the paralysis.

The abdominal wound is less likely to become contaminated than that on the thigh and through it both nerves can be divided with much greater certainty. To facilitate nursing until the wound is healed, the thighs are fixed in a position of moderate abduction. Thereafter the usual post operative treatment should be carried out.

(b) **Medial Rotation of the Thigh** The operation for this condition described by Sir Robert Jones in which the affected muscles were detached from the ilium has been superseded by that of Stoffel on the superior gluteal nerve on account of the improved results which it achieves. The nerve may be excised as it enters the buttock or at a lower level where it enters the medial rotators of the hip, the tensor fasciæ latæ and the anterior fibres of the gluteus medius and minimus. A vertical incision is made down to the periosteum from the iliac crest to the great trochanter. The terminal part of the superior gluteal nerve is found lying between the muscles and a portion is excised. The incision usually divides some of the nerve fibres passing to the anterior part of the gluteal muscles.

Fairbank has pointed out that in this type of case a certain amount of medial rotation may be due to spasm of the pectineus muscle. He therefore always resects the obturator nerve at the same time as the superior gluteal. Durham corrects the rotation by division of the tensor fasciæ femoris and the anterior fibres of the gluteus medius and minimus.

(c) **Flexion of the Thigh** Many cases of flexion deformity of the thigh can be corrected, easily and permanently by Soutter's operation as described under the treatment of infantile paralysis. The two muscles which cause the flexion are the tensor fasciæ latæ and the ilio psoas. Tenotomy of these muscles is easily performed and yields good results.

3 Deformities of the Knee

Knee flexion due to spasm of the hamstrings, is the usual deformity in spastic paralysis of this region. The surgeon must first decide whether the muscular contraction is one that can be abolished by stretching or whether it is permanent. In the latter event, a tendon operation will be necessary but when the contracture is due to spasm alone and can be corrected by pressure a Stoffel operation carried out on the sciatic nerve usually suffices. A straight vertical incision is carried down the back of the thigh from the gluteal fold for 5 or 6 inches. When the deep fascia has been incised the long head of the biceps muscle can be identified. This is retracted medially and, after separating the lines of muscle cleavage the sciatic nerve is found. From the medial side of the nerve, branches are sent out to supply the long head of the biceps, the semi membranous and the semi tendinosus. These nerves can be identified by means of the needle electrode. In moderate degrees of contracture the bicipital branch and the branch to the semi membranous are completely excised, while

in severe cases the whole nerve to the semi tendinosus, or at any rate part of it, may be removed as well

4 Foot Deformities

(a) *Pes Equinus*. Here also it is necessary to know the type of muscular shortening, whether it can be overcome by firm pressure or whether actual adaptive shortening of the tendons has supervened. In cases of organic shortening, the tendo calcaneus must be lengthened, but if the deformity is due to spasm alone, a Stoffel operation can be carried out on the tibial nerve, to paralyse to some extent the gastrocnemius and soleus. When the tendon has been lengthened in the manner previously described, the two portions are stitched together so that the upper flap is pulled on by the lower one just before the foot comes up to a right angle. It is also important to stretch thoroughly the other tight structures such as the posterior ligaments of the ankle joint, before the actual suturing is carried out. After the operation a splint is applied for about six weeks. Walking is then allowed with an inner wedge on the sole of the boot to prevent the formation of a valgus deformity, which sometimes follows this operation.

The Stoffel Operation. A vertical incision is made down the centre of the popliteal space through which the nerve can be approached easily owing to its superficial position. It is freed downwards and the two heads of the gastrocnemius split for a considerable distance until the branches are seen. The sensory branch, the nervus cutaneus surae medialis, is first encountered emerging from the medial and posterior aspect. In addition, two branches leave the main trunk to supply the lateral and medial heads of the gastrocnemius muscle. There are also the nerves to the dorsal portion of the soleus and to the plantaris. The ventral portion of the soleus is supplied by a branch coming from the antero-lateral aspect of the main nerve, while the tibialis posterior branch is found on the postero-lateral aspect.

Jones and Lovett recommend that in moderate cases of pes equinus the branches to the heads of the gastrocnemius should be resected, while in slightly more severe cases, one half of the nerve to the dorsal portion of the soleus should also be excised. In the most severe cases the entire supply of triceps surae may be removed. The knee should be kept extended on a splint, with the foot at a right angle, for three weeks to allow complete healing of the wound.

(b) *Lateral Deformities of the Foot*. If a varus deformity is present along with the equinus one it usually disappears after the Stoffel operation above described, although sometimes tenotomy of the tibial muscles may also be necessary. This is done by the open method in the same way as the tendo calcaneus is lengthened.

Valgus deformity may be corrected either by tenotomy of the peronei or by an operation on the peroneal nerve. The superficial peroneal nerve should be followed down in the substance of the peroneus longus till the last muscular branch to the brevis is reached. An

excision can then be done, the extent depending upon the severity of the spasm

AFTER TREATMENT After these operations, massage is of little benefit but prolonged training in walking and in the use of the affected limb should be undertaken. Splints should be used for several months after the correction of the deformity, but it is doubtful whether these should be worn all day. In most cases their use at night suffices. In the majority of cases a decided improvement is attained particularly in children whose mentality is fairly normal

CHAPTER XI

AFFECTIONS OF NERVES

LESIONS OF THE PERIPHERAL NERVES

The great frequency of peripheral nerve lesions during and after the Great War afforded an invaluable opportunity and provided a strong stimulus for the study of such injuries in all their phases and complexities. Consequently, many previous gaps in our knowledge have now been filled, and while long accepted views have in some cases been strengthened, in other cases old beliefs and practices have had to be modified or even wholly rejected. Nerve injuries occur, however, not only in warfare but also in civil life, so that their recognition and effective management are still of great economic and industrial importance. Their mode of origin must therefore be thoroughly understood in order that they may be recognized or, in many cases, prevented, the appropriate treatment must also be understood in order that nothing should be done to aggravate the already existing damage.

ETIOLOGY

A peripheral nerve may be injured by direct or indirect means.

(a) **Direct Injuries** The nerve may be wounded by a stab from a knife, by a bullet wound, or by the ragged ends of a fractured bone. In these cases it may be either completely severed, or only partially divided. In addition, however, it may be directly compressed by hæmorrhage or œdema following the reception of a wound. Another type of direct injury is when violent traction applied to a limb results in stretching or rupture of the nerve trunks, as in obstetrical paralysis.

(b) **Indirect Injuries** Although it may escape injury at the time of accident, the peripheral nerve may be surrounded by callus or enclosed by cicatricial fibrous tissue some considerable time after an injury to a bone or to the soft tissues in its neighbourhood.

PATHOLOGY

When it is wounded, changes ensue not only in the nerve itself but also in its coverings, and in the surrounding tissues. There is thickening of the neurolemma, and cicatricial fibrosis of the neighbouring connective and muscular tissues which have been coincidently

injured In this way a mass of fibrous tissue is formed about the nerve and it is often difficult to recognize or to isolate the nerve

In the absence of suture the divided nerve itself is usually the site either of a more or less bulky neuroma or of a pseudo neuroma A neuroma is a bulbous swelling resulting from the local proliferation and entanglement of regenerating nerve fibrils, and it forms round the central end It usually blocks the growing fibrils eventually

The pseudo neuroma arises as a result of the proliferation of the neuroglial elements in cases of partial division It gives rise to a swelling situated on the course of the nerve, and, since it contains no nerve fibrils, is really a glioma It may follow a simple contusion or compression, but is also found on the peripheral end of a completely divided nerve

Changes in the Nerve Fibril

Degeneration. It is an accepted principle that the peripheral segment of an interrupted nerve fibre undergoes centrifugal degeneration whether immediate suture is undertaken or not To this phenomenon the term Wallerian degeneration is applied It is due to the separation of the nerve from its trophic centres which, in the case of the motor fibres, are the anterior horn cells, and in the case of the sensory, the posterior root ganglia The individual components of the fibre undergo specific changes The axis cylinder first becomes fibrillated, then gradually attenuates and finally disappears The myelin sheath swells up in places and becomes irregular, while the myelin loses its special characteristics and comes to resemble the ordinary body fat Finally, it completely disappears, having been partly absorbed and partly eliminated by leucocytes The cells of the sheath of Schwann show active nuclear division and they share with the leucocytes the task of eliminating the myelin

The interrupted nerve fibre now consists merely of an empty protoplasmic frame surrounded by the proliferated cells of the sheath of Schwann This state is arrived at about two weeks after the injury.

In the central end degeneration advances proximally only to a slight extent Indeed this retrograde degeneration is practically confined to the immediate neighbourhood of the lesion

Regeneration. When a nerve is divided its recovery depends on the outgrowth of new nerve fibres from the central stump When the ends are approximated rapid union takes place by proliferation of the cells of the sheath of Schwann, but this is temporary and not regeneration The peculiar attraction which the empty sheath exerts on the growing axis cylinders is known as neurotrophism The cells of the sheath of Schwann in both stumps multiply, and in the peripheral stump they form the Schwann bands, or hands of Burgner, down which pass the young outgrowing axons It is believed that these Schwann bands may even bridge a gap of some length by forming broad strands of tissue or a fan of tissue There may be some accelerating, and perhaps

attracting, influence exerted by the central stump on the Schwann tissue growing from the peripheral stump—a reversed neurotrophism as it were. The peripheral outgrowth may take place fanwise, and it has been noted that one arm of the fan may reach forward until it joins with the central stump as though its growth were accelerated by this central stump. Regeneration across such bridges may be impaired if the new fibres are not guided into proper paths, as they might be by a true peripheral stump, but after all, as Cairns and Young point out, it is probable that the arrival of new fibres at appropriate end organs is always a matter of chance. About the fourth day after injury, the axis cylinders of the central end divide into fine fibrils which slowly advance right down to the level of the actual section, having traversed the small zone of retrograde central degeneration. They then proceed to bridge the gap, attracted and guided by the proliferating neuroglial cells, next they scatter about, seeking the empty sheath of the peripheral segment, which they ultimately penetrate. Thereafter they continue to grow until the nerve trunk is completely restored. At the same time the myelin sheath is re-acquired, and resumes its normal structure.

The length of time between the nerve suture and the complete return of function is variable and depends on many circumstances, but no matter how favourable the circumstances may be, regeneration is essentially a long and a gradual process. An axis cylinder is reckoned to grow at the rate of about 1 inch per month and, even after it has apparently had time to cover the full distance, there may be a considerable interval before there is anything like a return of function. Even in the most favourable cases, it is unlikely that all the functions—motor, sensory, and trophic—will be restored completely to their former perfection.

Changes in Dependent Structures

Complete division of a mixed nerve has the following effects: the muscles supplied by it are immediately paralysed, and begin to atrophy; they also show the reaction of degeneration; the area which derives its entire sensory supply from the nerve is rendered insensitive; while the structures over which it exercises trophic control—e.g. bones and joints—begin to atrophy.

CLINICAL EXAMINATION OF THE PATIENT

The efficient investigation of the condition of a nerve demands a perfect knowledge of its anatomy and physiology, i.e. its course, its branches, the muscles it supplies and the cutaneous territory to which it is distributed.

The examination of the nerve should be repeated frequently, say at intervals of several weeks, in order to note the evolution, the pro-

gress of the symptoms and signs of regeneration as they appear. Otherwise operative interference might be undertaken too soon.

The importance of examining the patient under proper physical conditions cannot be over estimated, and one would particularly emphasize the unreliability of electrical and sensory tests when the limb is cold. Prior to the examination, the limb should be put in a paraffin wax bath at 40° C, or under a radiant heat cradle, to ensure that the temperature of the part is sufficient, and to ensure standard conditions for accurate record and estimate of progress.

The investigation should commence with a carefully taken history of the injury, or the onset of the trouble. The symptoms and physical signs should next be elicited, and finally the actual clinical examination carried out.

While the history of the case is usually not important, it may sometimes be of value to know exactly how the injury was received—e.g. in the case of a bullet wound, to know the direction in which the bullet proceeded and the exact position of the limb at the time. It is also well to know whether or not suppuration occurred in the wound.

The clinical examination of the case is then proceeded with.

1. Attitude. Lesions of the various nerves usually result in a characteristic attitude. Ulnar injuries lead to a typical extension of the metacarpo-phalangeal joints of the fourth and fifth fingers, with flexion of the distal joints, median injuries to the characteristic flat hand, radial to a dropped wrist, and common peroneal to dropped foot.

2. Voluntary Power. This may be estimated by asking the patient to carry out in turn the movements performed by each individual muscle, a chart being made of the result. In cases where the muscle is very weak, it is useful, for purposes of comparison, to carry out the same action on the opposite side, and also to test the muscle in the position in which least strain is imposed upon it and therefore not against the force of gravity. In examining the deltoid, for example, the patient may be placed on his back and then asked to contract the muscle, while in testing the function of certain muscles, a polished surface may be inserted underneath the part to eliminate friction. In the case of radial nerve paralysis, the hand is laid on its ulnar side before the patient attempts to dorsiflex. In this way the slightest trace of voluntary contraction can be detected.

3. Reflexes. Paralysis of a muscle is attended by disappearance of its reflexes. In paralysis of the muscles dependent on the sciatic nerve, for example, the calcaneus jerk is lost, in triceps lesions the olecranon reflex disappears. It is to be noted, however, that if the skin is anæsthetic over the area of excitation, the reflex will be abolished, independently of any motor paralysis, so that loss of the reflexes is not pathognomonic of division of a mixed nerve, or of the paralysis of a muscle.

4 The Muscles A paralysed muscle shows certain characteristics

(a) It atrophies slowly and progressively until eventually it is nothing more than a fibrosed cord

(b) The muscular tone is completely abolished

'Tone' is the state of latent and permanent contraction which persists even when a normal muscle is at rest, its total disappearance is recognized by the complete flaccidity of the muscle bellies on palpation. It is also evidenced by the attitude of the limb the lifeless paralytic attitude becoming even more pronounced

(c) The paralysed muscle is painless when compressed except in cases of nerve irritation alone. Thus complete insusceptibility to pressure is one of the clearest signs of complete interruption and, conversely, if the muscle bellies are very sensitive, nerve irritation may safely be assumed to be present

5 The Skin In a case of complete paralysis examination of the integument is important. The skin is most commonly glazed, the cutaneous folds disappear, and the papillary crests are smoothed out giving a flat polished appearance to the finger joints. There may be excessive sweating, although this is more usual in cases of slight neuritis. The skin is much more frequently dry and sometimes a fine desquamation occurs

Certain vaso motor disturbances may be present giving characteristic appearances. Pallor is common but cyanosis and redness are only slightly less frequent in their occurrence. Edema may be found in cases of nerve interruption although it may be due only to abnormal posture or to disuse

Ulceration may be present in areas where the nerve has many sensory fibres—e.g. a typical trophic ulcer commonly develops over the heads of the first and fifth metatarsals in sciatic lesions. There may also be a diminution or elevation of the local temperature while hypertrichosis is common in all nerve lesions. In a case of nerve division a simple transverse groove is seen across the nail while in irritative lesions the nail may be striated, split, curved, or otherwise deformed. Frequently too, the nails atrophy and this, in association with the wasting of the subcutaneous tissue and the atrophy, gives a tapering, conical appearance to the finger tips

6 Sensation The most practical method of testing sensation is by means of a wisp of cotton wool and by an ordinary pin. It is not really important to investigate the finer grades of sensibility, or of thermo sensibility

When testing with a pin, in cases of nerve lesion, four zones can usually be differentiated. In the first or central zone the patient feels absolutely nothing. In the second zone, he feels the pin prick, not as a painful stimulus, but as a touch. In the third zone, which is beginning to derive a portion of its nerve supply from neighbouring nerves, he feels a vague pricking and for the first time can clearly

distinguish a piece of cotton wool. In the fourth, or most peripheral zone, the pricking is felt acutely, as the adjacent nerve is intact. Not infrequently there is slight hyperæsthesia at the margins where the areas supplied by adjacent nerves overlap the affected one.

7 The Nerve itself In examining the nerve, the first feature investigated should be its tenderness to pressure. Tenderness is present along its whole course when the nerve is subject to irritation, and, if elicited, it naturally indicates an incomplete lesion.

An attempt should next be made to elicit formication, or what is usually known as Tinel's sign. This is evidence of the presence of young axis cylinders, and therefore of an attempt at regeneration. It is particularly seen after the nerve has been repaired. If the nerve is gently compressed down to an inch below the level of suture after about a month, a sensation of "pins and needles" can be elicited in the area supplied by the nerve. This "formication" can gradually be elicited by more and more distal pressure as the regeneration proceeds. We are thus able to trace the furthest point of regeneration and so determine the rate at which the nerve is becoming repaired.

Lastly a neuroma is sought for along the course of the nerve. This may take the form of a simple fusiform thickening, or of a large bulky tumour or both. The presence of two neuromata indicates a complete lesion, but frequently the divided ends are so embedded in a mass of fibrous tissue that the swellings cannot be palpated.

8 Electrical Examination The investigation is completed by testing the electrical response of the muscles. Using the bipolar method the faradic or intermittent current is first employed, with one pole over the nerve and the other on the muscle belly. In cases of complete division no contraction is obtained. The galvanic, or continuous, current is then used, with a similar arrangement of the poles. Here a weak and sluggish response is obtained as compared with the normal rapid sudden contraction. There is also an alteration in the polar reactions, as contraction is stronger when the muscle is stimulated with the anode. In addition a greater intensity of current is necessary to produce the minimal contraction. These findings—the absence of faradic response, the weak galvanic response with a sluggish contraction, and a reversal of the polar formula—are collectively known as the "Reaction of Degeneration."

DIAGNOSIS

The diagnosis of a nerve injury should not be difficult, but only by a careful examination of the various functions of the nerve can certain confusing conditions be excluded. These are

- (1) Central paralyses, such as monoplegias and cord lesions
- (2) Peripheral polyneuritis due to some form of toxic poisoning
- (3) Functional paralyses. Some of these are hysterical or mimetic paralyses, and correspond to no definite anatomical distribution

They do not affect so much the movement as the function or use of the part. Atrophy and loss of tone such as occur in peripheral nerve lesions are absent and the area of anaesthesia corresponds to no anatomical nerve distribution but is oftener of the glove or stocking type.

(4) Pseudo paralyses from muscular contractures or tendon adhesions

(5) Ischaemic paralyses which arise from venous obstruction and result in fibrous contracture tendon adhesions and postural deformity

By far the most important and difficult problem to solve in cases of peripheral paralysis however is that of the nature of the lesion. In this connection four clinical syndromes are described and are considered to be fairly typical and clearly characterized. They are

- 1 The syndrome of interruption
- 2 The syndrome of compression
- 3 The syndrome of irritation
- 4 The syndrome of regeneration

It is all important from the point of view of treatment that each case be assigned to its appropriate group

1 Syndrome of Interruption When a nerve is completely divided there is an immediate and complete paralysis of muscles with rapid diminution in tone and progressive atrophy. In three weeks a typical reaction of degeneration is present. Anaesthesia follows immediately after the nerve is divided. Formication is absent below the lesion and there are no trophic disturbances.

2 Syndrome of Compression Here the paralysis may be as complete as in the syndrome of interruption but frequently it is only partial a few ill defined movements being possible. The muscle atrophy is far more rapid but less severe than in complete interruption. There is also some preservation of muscle tone and the reaction of degeneration is always incomplete. The anaesthesia is variable both in extent and in degree. Pain is absent at the level of the lesion and also along the course of the nerve and on pressure of the muscle belly. There is no formication or trophic disturbance.

3 Syndrome of Irritation This group presents a variable picture since there are varying grades of nerve irritation.

In the mild type there is spontaneous pain exquisite tenderness along the nerve trunk and certain trophic phenomena.

In the more severe types a condition known as causalgia develops. The patient suffers constant pain with even more acute exacerbations finally he will not allow his limb to be washed or even touched and its condition rapidly deteriorates. He looks anxious and is taciturn and irritable will not leave the house or even speak. He loses both sleep and appetite so that his condition is pitiable and pathetic in the extreme.

4 Syndrome of Regeneration The train of symptoms which accompany the healing of a nerve and the steady growth of the young axon cylinders into the distal degeneration segment of the injured nerve

are known collectively as the syndrome of regeneration. It is best seen in cases of successful nerve suture.

The various functions of the divided nerve steadily reappear, and the electrical reactions are restored to normal.

The first indications of regeneration appear only after an interval of four to six weeks, and amongst the earliest and best signs is the reappearance of formication. The steady descent of the point at which formication (Tinel's sign) can be elicited also enables us to measure the speed of the regeneration.

The electrical reactions improve in a variable order. The galvanic hypo excitability diminishes, the polarity becomes normal, the response to faradic stimulation is slower to return, and usually appears only after the first voluntary movements have been accomplished.

The paralysed muscles recover in a constant fashion, tone first making its appearance, followed by a return of sensibility, diminution in the atrophy, and finally voluntary movement.

The sensory functions are restored by a process of centrifugal extension. The first indication is often the occurrence of disagreeable spontaneous sensations or of cutaneous itch.

TREATMENT OF PERIPHERAL NERVE LESIONS

The treatment of nerve injuries may be said to be either conservative or operative. No hard and fast rules can be laid down for the adoption of active surgical intervention, indeed due consideration must be given in each case to the clinical findings, the history of the injury and, particularly, the time that has elapsed between its reception and the date of examination. If a case of nerve injury is not steadily improving at the end of six months it is unlikely that a satisfactory spontaneous recovery will take place and so operation should be undertaken then without further delay. It is unlikely that a good result will occur if suture of a nerve is delayed beyond eighteen months. Wherever there is any doubt about the continuity of the nerve trunk, operation should be recommended, it is not dangerous and it is impossible to be certain of the exact pathology of the lesion from clinical examination alone. Where a complete division of the nerve exists delay in operative treatment is harmful.

Conservative Treatment

In every case of nerve injury, the first procedure to adopt is the immobilization of the limb in the position which will most completely relax the affected muscles. Without this recovery is slow, and may be very incomplete. The splint varies with the anatomical site of the lesion—for deltoid paralysis an abduction splint, for radial paralysis a cock up splint, for a common peroneal paralysis a drop foot splint. Once the muscles have been thus relaxed they should never

be stretched until their voluntary power has returned, and the splint therefore must be worn during the night as well as by day.

Physiotherapeutic treatment is also essential. The limb is massaged to preserve the tone of the muscles, while the muscles themselves are passively exercised. Electrical treatment is also of considerable value. Either the continuous galvanic, or the interrupted faradic, current may be used according to the reaction of the muscle.

By far the most important part of this conservative treatment, however, is muscular re-education. The patient is taught to use the individual muscles, and so gradually restore them to normal. In the case of children this type of treatment may be camouflaged by the use of toys and musical instruments, which bring into action the desired muscles.

When the nerve is regenerating, the level on the nerve trunk at which formation can be elicited gradually creeps down the limb, inch by inch and month by month, and, when the growth of the axis cylinders has proceeded as far as the muscle bellies, the patient may begin to complain of a little tenderness when these are palpated. Later, the anæsthetic area becomes hyperæsthetic, and finally there may be a little twitching in the muscles as voluntary power returns. While these signs are showing themselves the electrical reactions are found to be gradually improving, but the faradic response does not usually return until the patient is able to move his muscles voluntarily.

It is impossible to assign any definite time limit to the process of regeneration, as many circumstances may alter the case and lead to delay.

When nerve suture is carried out soon after the original lesion, we may expect the nerve to regenerate at about the rate of 1 inch per month but even after the nerve has reached the extremity of the limb there is a lapse of some considerable time before voluntary power returns. The more distal the injury, the quicker and more complete is the recovery, but following a lesion in the upper limb it is rare to find a complete restoration of all the small muscles of the hand.

Operative Treatment

Indications for Operation. Peripheral nerves may be operated on at the time of the original injury or at a later date.

(1) **Primary Operations.** These are carried out in the presence of an external wound. While the primary excision, or the "debridement," of the wound is being carried out a nerve may be found divided. In these cases it is wise to suture it immediately. Nothing is lost by so doing, as, even if sepsis should develop in the wound, the sutures will prevent retraction of the nerve ends. The sepsis usually, but not invariably, prevents any regeneration.

(2) **Secondary Operations.** These are employed after the external wound has thoroughly healed. The indications for these opera-

tions are derived from the clinical examination of the individual case and the interpretation placed on the clinical syndrome

(a) *Complete Divisions* When it is evident that there has been a complete interruption of the nerve it is unwise to delay operative exploration. A fracture of the humerus with complete radial paralysis for instance should be explored as soon as the skin and general condition of the patient admit of operation.

(b) *Syndrome of Incomplete Interruption* If no definite improvement occurs in three months in cases of this type exploration should be carried out.

(c) *Syndrome of Irritation* In this type and particularly in causalgia operation should be resorted to as soon as possible.

Preparations for Operation The most essential part of the preparation is the thorough sterilization of the skin of the patient in order to reduce the possibility of sepsis to a minimum. The author is in the habit of using picric acid instead of iodine which is somewhat irritating to the nerve tissues. If any septic spots are present on the limb the operation should be postponed until they are soundly healed. One of the most common sources of post operative sepsis especially after a fracture is the presence of desquamating skin in the vicinity of the incision. About a fortnight after the fracture just at the time when the exploration of the nerve could be justifiably undertaken the oedema subsides and the skin begins to desquamate. It is of the utmost importance therefore that all the dead skin should be thoroughly removed during the preparation which should involve the whole limb. If the approximation of the nerve ends is likely to require flexion of a joint the joint should be prepared for this beforehand and any necessary manipulation carried out. Splints and plaster cases likely to be required after operation should be devised made and placed in readiness beforehand.

The Operation

The incision should be long and as a rule in the anatomical line of the nerve. Immediately after the skin incision is made the knife should be discarded and sterile towels at once clipped to the wound edges.

The nerve itself is then exposed above and below the lesion. If that is done and the nerve trunk encircled with and picked up by Lane's forceps on either side of the lesion there is usually no difficulty in freeing the nerve from the surrounding scar tissue. The dissection is performed delicately and carefully with a sharp knife. After the affected segment has been elevated from its bed the physiological activity of the nerve is tested by faradic stimulation with a fine sterile needle electrode. Where the faradic response is absent or where it is obvious that there is no intervening nerve tissue between the proximal and distal stumps then the operation of nerve suture must be carried out. If the response in the muscle supplied by the nerve is brisk however then there is no need for complete suture and neurolysis

may be carried out. In some cases the lesion will prove to be only a partial one, several fibres being intact. In this event the intact fibres are left alone, and resection and suture of the injured segments alone carried out.

(a) **Neurolysis** This term is applied to the operation in which the nerve is freed from enveloping scar tissue. In many cases it may also be incised or sliced in a longitudinal direction, to relieve the pressure of the contracting fibrous tissue on the nerve fibres. Thereafter, the affected part of the nerve is buried in healthy muscular tissue, away from its previous bed of scar tissue.

(b) **Nerve Suture** The first step in this operation is to mobilize and thoroughly relax the nerve by wide dissection of the proximal and distal ends. In the majority of cases this procedure, along with flexion of the appropriate joints, will enable the ends to be approximated. When coaptation has been secured, a stitch is put into the healthy nerve segments below and above the lesion to prevent axial rotation of the nerve during the insertion of the later sutures. The nerve is now trimmed, i.e. it is cut through at the level of the lesion, and the cross section examined. Successive slices are removed until normal fibrils are evident to the naked eye, indicating that the part is sufficiently healthy to be sutured. This procedure is carried out at both ends of the nerve, and when both present normal fibrils, the ends are ready for stitching. A series of interrupted linen stitches are passed through the nerve sheath, since the mere approximation of the cut ends is all that is required. After stitching the affected portion of the nerve is buried in healthy muscle tissue and the wound closed.

When necessary, the flexion of joints must be rigidly maintained by splints to prevent disruption of the suture line.

Young and Medawar have devised experimentally a method by which nerve ends may be held together with concentrated coagulated blood plasma. They say this reduces the difficulty of nerve suture and minimises the disorganisation of fibres by sutures. The method consists in holding the cut stumps together and pouring round them plasma which has just been mixed with a little strong tissue

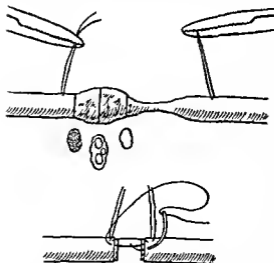


FIG. 253—Suture of Peripheral Nerve

The suture penetrates the sheath only. The nerve is sectioned first until healthy fibres are evident. In the transverse sections will be seen homogeneous fibrous tissue swollen fibrils and healthy nerve from right to left.

extract This plasma clots to a firm jelly in about 2 minutes and holds the stumps together It is freely permeable and during subsequent days dissolves though remaining long enough to allow a firm union to be established It is said that the new fibres grow across the junction rather more quickly than across a suture line

Method of obtaining End-to-End Suture In many cases the loss of nerve tissue will have been so great that end to end suture can be obtained if at all only with great difficulty There are various methods by which the approximation of the ends may be facilitated

(i) *Extensue Mobilization of the Nerve* A gain of about 1 inch in the arm or 2 inches in the leg may be obtained by a wide mobilization of the nerve trunk on either side of the lesion This feature depends on the inherent elasticity of the nerve tissue

(ii) *Relaxation of the Nerve*, by the temporary fixation of joints in favourable positions Flexion of the elbow will occasionally facilitate suture of the nerves which pass in front of it, even when there is a gap of 2 inches Flexion of the wrist similarly gives an extra inch to the median and ulnar nerves while adduction of the arm at the shoulder gives an extra inch to the nerves crossing the axilla After fixation for six weeks joint movements are commenced and the range of these will be found to increase rapidly without separating the sutured nerve ends

(iii) *Alteration in the Course of the Nerve* The ulnar nerve may be brought in front of the medial epicondyle the radial nerve may be brought to the front of the arm, and the median brought in front of the flexor muscles of the forearm

(iv) *Stripping up of Branches* Where the branches anchor the nerve ends and prevent their mobilization and approximation they may be gently stripped up from the parent nerve

(v) *Sacrifice of Branches* When suture is prevented by the tension of distal branches it may be better since the branches are already functionless to suture the rest of the nerve at their expense particularly in a nerve such as the median where the return of sensation is a matter of great importance

(vi) *The Two stage Operation* This method may be used where it is absolutely impossible to secure direct suture the principle being to bring the untrimmed ends of the nerve into contact, or as near as possible to each other, by the methods of relaxation described above and then anchor them by strong sutures In two or three weeks the joints are gradually extended and the nerves thus coincidentally stretched As soon as the full range of joint movement has been restored, the nerve is again explored and, by repeating the process of mobilization, the nerve ends will in the majority of cases be capable of approximation

(vii) It is doubtful whether such operations as bone shortening and nerve anastomosis are of any real benefit in cases where there has been extensive nerve damage, and even nerve grafting should only be resorted

to as a last resort. The work of Ballance and Duel on the facial nerve has shown that more can be expected of nerve grafts than was hitherto thought possible. Similar good results have been recorded in grafted medial and musculo spiral nerves. Indeed according to Young Holmes and Saunders a fresh autograft is only slightly less satisfactory than a normal peripheral stump. The presence of two junctions however might lessen the chances of a successful end result and might necessitate a second operation to excise the second junction. The success of the thin Ballance Duel grafts would suggest that a graft of several sections of a small nerve (e.g. external cutaneous of the thigh) might be more satisfactory than one single thick graft.

In closing the wound great care should be taken to secure absolute hæmostasis. The muscular tissues are united over the nerve and as thick a covering as possible obtained by this means. An accurate skin apposition is made easy if transverse scratches have been made across the line of the proposed incision before the skin was actually divided.

AFTER TREATMENT. The after treatment of nerve injuries is of more value in preventing complications than as a direct aid to regeneration as perfect anatomical regeneration may occur and yet the limb remain functionally useless. Complications such as joint and tendon adhesions and muscle atrophy are often more disabling than the nerve injury. Baths, massage, gymnastic and electrical treatment are of great value in preventing or minimizing such complications and are essential adjuncts to operative treatment.

The two most important principles in the after treatment of nerve suture are

- 1 To prevent particularly where the suture has been performed under considerable tension the separation of the sutured nerve ends by careless stretching of joints.

- 2 To prevent the over stretching of weakened muscles by the over action of their opponents or by gravity.

To obviate these complications splints are applied. These are usually made of malleable metal although plaster may also be used. The malleable metal is valuable as the joints can be extended gradually by simply straightening out the splint. It is a matter of some difficulty to know when to start extending joints but the authors rule has been to start the extension about the seventh or eighth week and increase it by just a few degrees every three or four days. Any pain or sensation of over stretching in the flexor aspect of the joint indicates that the procedure should be delayed.

All muscles which would otherwise be over stretched by the force of gravity should be supported and relaxed by splints until such time as voluntary power returns. In all paralyses but more particularly when the intrinsic muscles of the hand are affected muscle re-education is of the greatest value in accelerating a return of voluntary movement. This can be carried out only by a trained masseuse and needs no elaboration here.

THE CONSIDERATION OF INDIVIDUAL NERVES

The Median Nerve

ETIOLOGY

The median nerve is most frequently injured in wounds of the forearm especially penetrating injuries such as those caused by broken glass. It may also be injured in fractures of the lower end of the humerus and occasionally in fractures of the radius and ulna, while a lesion of this nerve is not uncommon in Volkmann's ischaemic contracture.



FIG. 254.—The Median Nerve

The typical clawed index finger whose flexion is limited or nonexistent

CLINICAL FEATURES

A complete division of the median nerve above the elbow involves the flexors of the wrist, fingers and thumb, the pronator teres and the pronator quadratus, as well as the opponens pollicis, flexor pollicis brevis and the superficial head of the abductor pollicis.

Atrophy of the whole thenar eminence is usually a conspicuous sign, but the deep head of the flexor pollicis brevis may occasionally remain intact owing to its deriving an anomalous supply from the ulnar nerve.

The sensory loss involves the thumb, index and middle fingers, and half the ring finger. Injuries of the median nerve are notable for the frequency with which irritative syndromes of all grades develop. Trophic disturbances are best seen in the wasting of the terminal phalanx of the first finger, which is usually thin, pointed and conical.

DIAGNOSIS

The characteristic attitude of a hand deprived of its median nerve supply is one of flattening, the thenar eminence being entirely wasted and the thumb rolled laterally from paralysis of the opponens pollicis.

The first finger almost entirely loses its power of flexion and when an attempt is made to close the fist the thumb and the index finger remain extended. Also when the palm of the hand is laid on a table the patient is unable to flex the first finger with the other fingers remaining flat on the table.

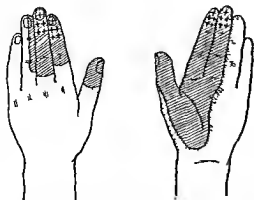


FIG. 200.—Sensory loss in division of Median Nerve

The dotted area is that insensible to pin the shaded area that insensible to pin prick and cotton wool the crosses indicate the region insensible to deep pressure

A good clinical test for the loss of median sensation is to ask the patient to button his coat this manoeuvre cannot be carried out unless the movements are directed by vision.

In injuries at the level of the wrist joint a limited muscular paralysis may pass unnoticed the anaesthesia however is usually just as complete as in lesions at a higher level though deep touch may sometimes be appreciated since this sense is carried in the tendons.

In complete median lesions the functional incapacity of the hand is quite out of proportion to the actual motor paralysis. The index finger is particularly helpless a disability resulting chiefly from the loss of deep sensibility.

TREATMENT

Lesions of the median nerve are treated on the lines already indicated but there are additional points to be considered.

(a) In lesions of the nerve at the elbow if suture is impossible owing to the presence of a large defect it is sometimes possible to bridge the gap by transposing the median nerve in front of the pronator teres. The operation is one of some difficulty since most of the branches to the forearm muscles are given off at this level. It would therefore be permissible in lesions of the nerve above that level only if the operator were prepared to sacrifice the muscular branches in order to give the patient a chance of recovering sensation in the median area. Should this be the alternative to leaving the nerve unsutured then it would be worth while.

(b) In cases where end to end suture is impossible the complete muscular paralysis may be ignored and an attempt made to obtain a return of sensation by anastomosing the sensory branch of the radial with the median nerve at the wrist. The superficial branch of the radial nerve is defined on the radial border of the forearm at the level of the wrist and divided low down the proximal end being implanted into the median nerve in front. Some authors report good results from this operation but the writer has not been impressed by the four cases in which he adopted the procedure.

(c) In lesions of the nerve where sensation is complete but where the small muscles are paralysed, the chief disability is inability to oppose the thumb. Considerable benefit can be obtained in such cases by a simple transplantation operation after the manner of Ney. An incision is made along the dorso lateral aspect of the thumb from the level of the metacarpo phalangeal joint to the level of the wrist joint. The tendon of the extensor brevis pollicis is isolated and divided at the upper level of the incision. An incision is now made on the anterior aspect of the wrist from the level of the joint upwards for two inches. Ney used the palmaris longus but the author found the function after its transplantation less satisfactory than by using a shp from the flexor carpi ulnaris. Accordingly this tendon is identified and split longitudinally and one of the halves severed at its insertion. A subcutaneous tunnel is now made from the distal end of the first incision to the distal end of the second and the tendon of the extensor brevis pollicis threaded through it. The first incision is now stitched up. With the thumb fully rotated into the opposed position the proximal end of the divided thumb tendon is stitched to the distal end of the divided part of the flexor carpi ulnaris under a fair amount of tension. After stitching the wound the thumb is retained in this position for about four weeks in plaster of Paris.

In similar cases where paralysis has produced a flat hand with a non appposable thumb it has been suggested that good function is produced by grafting the 1st and 2nd metacarpals together in an optimum position by means of a thick graft inserted through the first interosseous space. The author was satisfied with the result in one case.

The Ulnar Nerve

The ulnar nerve is most commonly injured in incised wounds of the forearm or in fractures of the lower end of the humerus particularly those affecting the medial epicondyle. Occasionally it is contused by crutch pressure in the axilla and it is frequently implicated in osteo arthritic outgrowths about the elbow joint.

Occasionally also the nerve is anchored so insecurely in the post condylar groove that it can shp backwards and forwards with each movement of flexion and extension. This instability often results in neuritis with pain, and weakness of the fingers.

CLINICAL FEATURES

In lesions above the post-condylar groove the paralysis affects the flexor carpi ulnaris and the medial half of the flexor digitorum profundus, the hypothenar muscles the interossei the medial two lumbricals, the adductor of the thumb and sometimes the deep head of the flexor pollicis brevis. Abduction and adduction movements of the fingers are lost and also adduction of the thumb so that the patient is

unable to grasp a pencil placed crosswise between the thumb and the index finger. In paralysis of the dorsal interossei, abduction of the fingers can be carried out by the extensor digitorum communis but this produces also hyper extension of the metacarpo phalangeal joints.

The muscular atrophy gives the familiar flattening of the hypothenar eminence, the depressed interosseous spaces, and the prominence of the metacarpal heads in the palm. A claw hand deformity, best marked in the ring and little fingers, develops later. The proximal phalanges are then extended and the distal and middle phalanges flexed, while the little finger is usually abducted. As time goes on



FIG. 256.—Anæsthesia in Ulnar Nerve Injuries.

In the left hand figure is shown the typical extent of the absolute sensory loss. In the right hand figure the dotted area is insensitive to light touch (epicritic) and the shaded area is insensitive to pain (protopathic).

this contracture becomes more and more marked, and the fourth and fifth fingers gradually flex down into the palm and become rigidly fixed in this attitude.

Sensation is lost over the ulnar border of the hand, the entire little finger and ulnar half of the ring finger, on both extensor and flexor surfaces.

If the lesion is below the origin of the large dorsal cutaneous branch, sensation is retained on the dorsum of the hand and the area of analgesia is exceedingly small.

DIAGNOSIS

The functional disability following division of the ulnar nerve is slight, indeed many such cases of complete ulnar paralysis were able to return to full duty before the end of the last War.

Traumatic Ulnar Neuritis

Certain types of ulnar nerve lesion, of the nature of friction neurites, result from some alteration in the normal relations between the nerve and its post condylar bed. Platt states that three distinct groups of these may be recognized.

1 Lesions associated with recent fractures of the lower end of the humerus, e.g. fractures of the medial epicondyle

2 Late ulnar palsy, following fractures of the lateral condyle sustained usually in early childhood. In this type of lesion, three stages can be characteristically recognized

(a) The fracture in early life

(b) A latent period, rarely less than ten years

(c) The development of the lesion

The neuritis is here due to friction or tension, and is a sequel to the gross valgus deformity resulting from the fracture. The nerve trunk, compelled to take a longer course, becomes over stretched in the abnormally shallow post condylar groove

3 Recurring dislocation of the nerve

In these injuries, the clinical picture is one of a mild irritative lesion. The nerve trunk becomes exquisitely tender and thickened, and later a definite nerve spindle or neuroma may develop



FIG 257.—Post traumatic Ulnar Neuritis
A fracture of the lateral condyle of the humerus resulting in cubitus valgus and the later development of ulnar neuritis

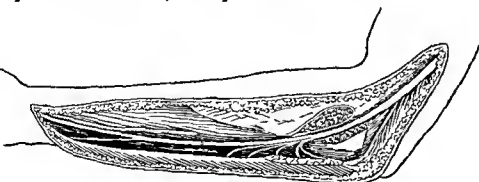


FIG 258.—Diagram showing the method of transposing the Ulnar Nerve to obtain end to end Suture after considerable loss of Nerve Length.

TREATMENT

Lesions of the ulnar nerve are treated on the lines already laid down. In addition, however, anterior transposition of the nerve has a wide application

This operation is indicated in all extensive injuries where there is a considerable gap to be bridged, in all lesions of the nerve in the region of the post condylar groove, and in recurring dislocation of the nerve. The incision follows the course of the nerve in the upper



FIG. 259—Lesion of the Median and Ulnar Nerves

sacrificed but the motor branches are stripped up as far as possible so that the nerve trunk can be displaced easily to the front.

A new bed is then constructed in front of the epicondyle, by division of the aponeurosis covering the common origin of the flexor muscles and the superficial muscular fibres themselves. The nerve is now laid in its new bed. It will be seen how ever that as it runs forwards it crosses the tense bridge formed by the medial intermuscular septum and it is necessary to resect a portion of the septum large enough to accommodate the nerve trunk. The divided muscle fibres and fascia are then sutured over the nerve.



FIG. 260—Lesion of the Median and Ulnar Nerves from Gun shot Wound

The Radial Nerve

The radial nerve is one of the most frequently injured of all nerves. Its intimate relation to the humerus explains its common association with lesions especially fractures, of that bone. If it escapes injury when the actual fracture is sustained, it may later become involved in the scar contracture of the soft tissues or in callus formation at the site of the fracture. The nerve may be injured also by the pressure of a crutch in the axilla, while it may be contused when the arm is left hanging over the back of a chair for a long period, as in a drunken sleep.

CLINICAL FEATURES

The paralysis affects the extensor group of muscles—the brachio radialis the radial and ulnar carpal extensors, and the extensors of the thumb and fingers—so that there at once results a characteristic drop wrist. Paralysis of the triceps muscle is very rare, as all the branches

supplying it arise before or just as the main trunk enters the radial groove

The sensory signs are trivial. When the lesion is in the upper third of the arm there is a small ill defined triangular zone of anæsthesia on the dorsum of the hand over the first interosseous space. In lesions below the origin of the lowest lateral cutaneous branch there is little sensory loss at all while trophic changes are also absent.

DIAGNOSIS

The diagnosis is rarely in doubt. The wrist drop of lead palsy is usually bilateral and the paralysis incomplete the brachio radialis remaining unaffected. It should be remembered that the interphalangeal joints of the fingers are extended by the interossei and lumbricals and that it is the metacarpo phalangeal joint that is extended by the muscles supplied by the radial nerve though the lumbricals have an unopposed action on the metacarpo phalangeal joint in radial lesions as flexors. The grip is very materially weakened in radial paralysis because the flexors of the fingers are placed at a mechanical disadvantage.

TREATMENT

Since the nerve is almost wholly a motor one the results of suture are very good. Lesions of the nerve are treated on the lines already laid down but in extensive lesions where there is a considerable gap in the nerve tissue the defect can sometimes be diminished by transposing the nerve.

Transposition of the Radial Nerve. The nerve between the lesion and the axilla is exposed by an incision on the medial side of the arm care being taken to avoid injuring the motor branches which come off opposite the insertion of the latissimus dorsi. The nerve is traced to the site of the lesion which is usually in the upper part of the radial groove. Through a separate incision overlying it the nerve is then exposed at the junction of the middle and lower thirds of the arm and again traced upwards to the site of injury. The two dissections can usually be made to meet without actually joining the



FIG. 61.—Compound Fracture of the Humerus with Involvement of the Radial Nerve and Wrist Drop

skin incisions, and without cutting the lateral head of the triceps. The affected portion of the nerve is excised and an oblique tunnel made in an upward direction along the front of the humerus through the deepest part of the brachialis muscle. Forceps are passed down the tunnel, and the lower end of the nerve grasped and pulled upwards until it emerges near the upper end. At this point, it is sutured to the upper stump.

If the lesion is situated at the lower end of the groove, the upper stump is pulled from above downward through the tunnel and united to the lower stump at the lower end of the groove. After the operation, the elbow is maintained in a position of full flexion, with the forearm pronated. By this procedure, a full inch may be gained, that is to say, ends which would have remained an inch apart without transposition can by employing this method, be sutured together.

After all operations on the radial nerve, a special splint is necessary to maintain the hand and wrist in dorsiflexion. The fingers should be kept a little short of full extension, while the thumb should be kept extended in the position it takes up when grasping a tumbler.

Where the lesion of the radial nerve is so extensive that even after transposition the divided ends cannot be brought together, the motor paralysis can be dealt with most satisfactorily by tendon transplantation. Most gratifying results are obtained by this operation when the patient is suitable, i.e. where he has the necessary intelligence to take full advantage of the new muscular movements.

Tendon Transplantation for Complete Radial Paralysis. With the forearm pronated, a dorsal mid line incision is made from the back of the wrist joint, to the middle of the forearm, from there it deviates to the radial side for about 2 inches, in order that the insertion of the pronator teres may be freed easily from the middle of the radius. The interval between the bellies of the extensor communis and the extensor carpi radialis brevis is defined and opened up, and the insertion of the pronator detached from the radius with a periosteal elevator. The tendon is flat and broad, so that care must be taken to obtain it long enough and strong enough for suture. When the tendon has been detached it is pulled on, and the belly freed by blunt dissection from the flexor carpi radialis, with which it is intimately associated. The radial carpal extensors are freed by opening the deep fascia over them and the two muscles retracted.

Anastomosis forceps are now placed on the free pronator, and the dissection of the extensor tendons continued down to the wrist joint. The common extensor sheath is opened just above the dorsal carpal ligament, and each tendon isolated so that individually it pulls freely to its insertion. The common extensors are then retracted medially, and the extensor longus pollicis picked up, with the extensor indicis proprius lying along its ulnar aspect. The skin edges of the dorsum are now held together with Lane's forceps, while incisions are made on the front of the forearm.

An incision is next made along the radial border of the flexor carpi ulnaris tendon which is dissected free from its muscular fibres up to the middle of the forearm and divided opposite the wrist joint. The skin between the volar and the dorsal wounds is next undermined so that communicating tunnels are formed between the front and back of the forearm. The flexor carpi ulnaris is passed through the tunnel and clipped with anastomosis forceps to the dorsal incision.

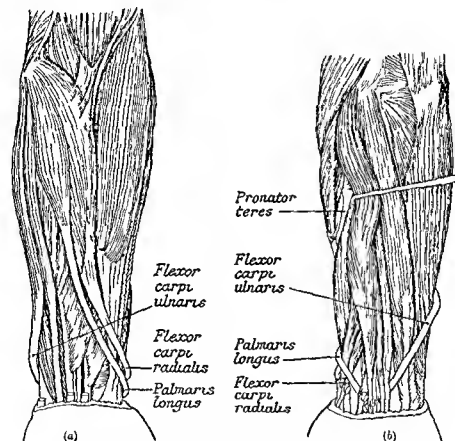


FIG. 267.—Method of Tendon Transplantation for Radial Paralysis.

(a) Anterior view showing the site of dissection and transposition round the lateral and medial aspects of the lower forearm.

(b) Posterior view showing the transplantation of the 3 long tendons at the wrist and of the pronator teres at the elbow.

A third incision is made along the radial border of the flexor carpi radialis tendon in the lower two thirds of the forearm. The tendon is isolated, divided at the level of the wrist joint and freed up to the level of its fleshy belly. If the palmaris longus be present it is similarly freed and detached but when absent the tendon of the flexor carpi radialis may be split longitudinally and so divided into two separate portions.

A tunnel is now made round the radial border of the limb to the back of the forearm and the palmaris longus and the flexor carpi

radialis threaded through it and clipped in the dorsal incision. The anterior wounds are now closed.

For the rest of the operation the wrist, fingers and thumb are kept in the fully dorsiflexed position by a second assistant. The pronator teres is now threaded through the two radial extensors after the latter have been pierced by a tenotomy knife. The tendons are held taut, the pronator being pulled distally and the extensors proximally until thread stitches are inserted.

The tendons of the *abductor pollicis longus* and *extensor pollicis brevis* are exposed above the wrist joint. Their tendon sheath is opened and the muscles freed. Into them the *flexor carpi radialis* is now transplanted. A slit half an inch long is made in the two paralysed tendons by a tenotome and through it the *flexor carpi radialis* is pulled. The tendons are then pulled taut, and with the thumb in extension they are stitched with No. 60 linen thread. From this point to the end of the operation the thumb must be kept fully extended at both its joints.

The *palmaris longus* is transplanted into the *extensor pollicis longus* and the *flexor carpi ulnaris* to the *extensor digiti quinti proprius*, the tendons of the *extensor digitorum communis* and the *extensor indicis proprius*.

After the wound has been sutured liberal dressings are applied and the limb put in a cock up splint so that the fingers, thumb and wrist are kept rigidly dorsiflexed. The dressings are left on for several days—in fact they need not be removed unless there is some special indication until the time for the removal of the stitches i.e. in about ten days.

There is considerable pain for about forty eight hours but this can be controlled satisfactorily by the use of morphia provided the dressings have not been applied too tightly. The tips of the patient's fingers should be left exposed so that the condition of the circulation can be watched.

Summary of the Transplantation. 1 The pronator teres is transplanted into the *extensor carpi radialis longus* and *brevis*.

2 The *flexor carpi radialis* is inserted into the *abductor pollicis longus* and the *extensor pollicis brevis*.

3 The *palmaris longus* if present is transplanted to the *extensor pollicis longus*.

4 The tendinous portion of the *flexor carpi ulnaris* is inserted into the *extensor digitorum communis*, *extensor indicis proprius* and *extensor digiti quinti proprius*.

The Axillary Nerve

The axillary nerve may be injured in dislocations of the shoulder and in fractures of the neck of the humerus. Cases are also on record in which the nerve has been inadvertently divided in exposing the shoulder joint.

CLINICAL FEATURES

The nerve supplies the deltoid, and teres minor muscles, as well as the shoulder joint and the skin over the deltoid. Paralysis of the deltoid is therefore the main result of a lesion of the nerve. The patient is unable to abduct the arm at the shoulder joint while there is diminution in the power of flexion and extension these movements being to a considerable extent initiated by the deltoid.

Sensation is decreased in the skin over the middle of the deltoid the loss is seldom complete, there being only hypæsthesia of the lateral surface of the shoulder.

TREATMENT

The nerve may be exposed in the axilla or at the level of the surgical neck of the humerus.

(1) *In the Axilla* With the arm abducted and laterally rotated, an incision about 7 inches long is made in the line of the great vessels with its mid point over the proximal border of the latissimus dorsi tendon. The pectoralis major is retracted upwards but if it obstructs the view it should be divided at its insertion into the humerus. The axillary nerve is found by tracing the radial nerve upwards to its origin—which is also the origin of the axillary—from the posterior cord of the plexus. The latissimus dorsi tendon may also be used as a guide, since the nerve as it enters the quadrilateral space lies above, and close to the medial border of the tendon.

(2) *Exposure at the Surgical Neck* The arm is adducted and placed across the chest. A longitudinal incision 5 inches long is then made along the dorsal border of the deltoid. The deltoid may be retracted upwards or its most posterior fibres may be separated from the rest of the muscle and the nerve sought against the humerus as it emerges from the quadrilateral space to wind round the surgical neck.

If the nerve is injured at the point where it breaks up into its terminal branches suture may be impossible and the central stump should then be directly implanted into the muscle. It is doubtful whether such a direct implantation is likely to be effective, but, at any rate it should be given the chance.

Residual Paralysis When there is no recovery after operation, the surgeon is left with a choice of two procedures to overcome the inability to abduct the arm. The trapezius muscle, either directly or after lengthening it with some fascia, may be transplanted into the upper end of the humerus or the shoulder joint may be arthrodesed in a position of abduction. The author is of the opinion that arthrodesis is the sounder procedure when the axillary nerve is irreparably injured.

During the after treatment of any of these operations the arm should be kept in right angled abduction and also on the plane of the shoulder joint i.e. 40 degrees in advance of the coronal plane, by means of an abduction splint.

Lesions of the Brachial Plexus

The plexus may be injured directly by an incised wound by bony callus in fractures of the first rib or clavicle or by scar contraction. It may also be affected more indirectly by forcible traction of the arm by extreme lateral flexion of the head or by violent downward pressure on the shoulder as by a heavy weight or in parturition. Not infrequently a dislocation of the humerus is the causative agent.

The brachial plexus is formed by the anterior primary divisions of the fifth sixth seventh and eighth cervical and first thoracic nerves which join and then subdivide according to a constant plan. The plexus may be reinforced by a contribution from the fourth cervical when it is known as a pre fixed plexus or a reinforcement may be present from the second thoracic in which case it is known as a post fixed plexus. Such fixations are only part of a widespread shift in segmentation caudal or cephaloid.

The Root Supply of the Plexus Many of the large muscles are innervated from several segments but usually isolated injuries of the plexus bear very heavily on certain muscles. The following table gives the commonest effects of section of the individual roots in terms of paralysis.

- C5 Rhomboids deltoid spinatus biceps brachialis clavicular head of the pectoralis major
- C6 Sternal head of pectoralis major and triceps
- C7 Extensors of wrist and fingers
- C8 Flexors of wrist and fingers
- T1 Intrinsic muscles of hand (and cervical sympathetic)

The lowest root of the plexus carries in it for a short distance some of the sympathetic fibres which have left the cord in the anterior roots of the first and second thoracic segments. Rupture of the former root will therefore be accompanied by Horner's syndrome as well as by paralysis of the small muscles of the hand. The lesion must be close to the spine to affect the sympathetic fibres as these leave the nerve after a very short course.

Injury may affect the nerve roots proper their anterior primary divisions the primary plexus trunks the cords or the branches of distribution either separately or in combination. The injuries are more commonly grouped on a topographical basis as supra clavicular and infra clavicular lesions.

Supra clavicular Lesions

These are caused by

- (a) Traction lesions from over stretching as in the familiar obstetrical palsy
- (b) Penetrating wounds
- (c) Friction or compression lesions associated with rudimentary cervical rib

Infra-clavicular Lesions.

These are produced by

(a) Contusion or compression lesions, associated with shoulder-joint dislocation

(b) Penetrating injuries

These lesions are divided clinically into three groups, according to their clinical features—the lesion of the complete plexus, the upper arm syndrome, and the lower arm syndrome

1 The Complete Plexus Syndrome.

(a) *Motor Signs* There is a complete paralysis of all the muscles of the hand, forearm, and upper arm. The rhomboids and the serratus anterior remain unaffected however, unless the injury is at the level of the cervical transverse processes

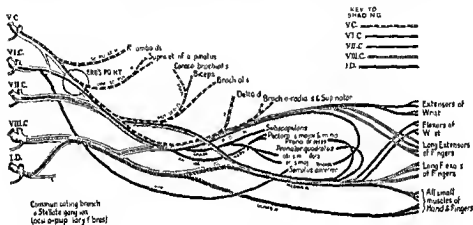


FIG. 263—Obstetrical Paralysis (Upper Arm Type)

Schematic diagram illustrating the distribution of the brachial plexus. The ring indicates the common situation of injury (after Q. Terva's)

(b) *Sensory Signs* There is a wide zone of anaesthesia involving the hand, forearm, and part of the arm

(c) *Vaso motor and Trophic Signs* If the lesion is complete, these symptoms are slight. More commonly, from irritation by scar tissue, gross fibrosis and degenerative changes are manifest in the tissues of the hand

(d) *Sympathetic Signs* When the eighth cervical and first thoracic nerves are injured close to the intervertebral foramina, the oculo-pupillary and other sympathetic fibres which run with them are implicated. The pupil is contracted, and fails to react to light

2. Upper Arm Syndrome. (Erb Duchenne type)

This syndrome is evidence of a combined lesion of the fifth and sixth cervical nerves, either below their junction or at Erb's point, that is to say, proximal to the origin of the suprascapular but distal to the origin of the long thoracic and dorso scapular nerves, the serratus anterior and the rhomboids are unaffected

(1) *Motor Signs* There is paralysis of the deltoid teres minor supraspinatus infraspinatus and the clavicular head of pectoralis major. The arm is therefore rotated internally by the latissimus dorsi and sternal head of pectoralis major. Biceps and brachioradialis are paralysed and brachialis is weakened. The elbow is extended by the triceps. The supinators of the forearm are affected and the forearm is pronated by pronator quadratus (pronator teres being supplied by C6) alone. The radial extensors of the wrist are paralysed resulting in ulnar deviation of the hand.

(b) *Sensory signs* are absent if the lesion is confined to the anterior primary ramus of C5 but if C6 is affected there is some loss of sensation on the lateral aspects of the arm and forearm. Vaso motor and sympathetic signs are absent.

3 The Lower Arm Syndrome (Trin Duchenne)

This is most commonly seen in obstetrical paralysis. The lesion usually affects the first thoracic nerve but may involve the whole lower trunk (C8 and T1).

(a) *Motor Signs* The intrinsic muscles of the hand are paralysed and a claw hand deformity results the interphalangeal joints being flexed and the metacarpophalangeal joints hyperextended. Paralysis of the flexors and extensors of the fingers may follow lesions of the entire lower trunk.

(b) *Sensory Signs* The zone of anaesthesia includes the ulnar side of the hand and forearm and a narrow strip of the arm.

When the first thoracic nerve is injured proximal to the point of origin of its white ramus communicans oculo pupillary symptoms are a characteristic feature and the paralysis is known as Klumpke's paralysis.

The Cervical Sympathetic

The sympathetic trunk may be injured by penetrating wounds in the lower part of the neck or in the course of operation in the deep triangle. The oculo pupillary fibres which leave the spinal cord through the anterior roots of the first and second thoracic nerves are also occasionally injured in lesions of the brachial plexus.

Signs of paralysis of the cervical sympathetic (Horner's Syndrome)

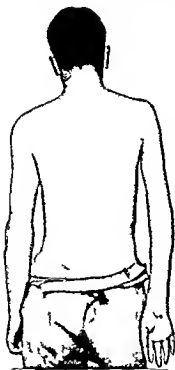


FIG. 64.—Lesion of the Brachial Plexus.

The arm and hand are completely paralysed and wasted and held in the characteristic attitude.

are obvious on inspection, and are due to interference with the conduction

- (1) Drooping of the upper lid
- (2) Narrowing of the palpebral fissure
- (3) Retrogression of the eyeball
- (4) Contraction of the pupil
- (5) Loss of the cilio spinal reflex Normally the pupil dilates when the skin of the neck is pinched, but when the sympathetic is paralysed this reflex is lost

(6) Absence of sweating in the whole of the upper limb, the upper part of the chest, neck, and half of the face, the area being accurately delimited by the middle line

When the sympathetic trunk is irritated, as by the presence of scar tissue, an exactly opposite train of symptoms arises

OBSTETRICAL PARALYSIS

Paralysis of one or both upper extremities occasionally follows the birth of a child. This is more common when the labour is complicated by obstetrical difficulties which necessitate forcible manipulation or traction on the arm. The condition is accordingly known as "obstetrical paralysis"

ETIOLOGY

The paralysis is the sequel to a lesion of the cords of the brachial plexus whereby they are stretched, and not due to the results of a dislocation of the shoulder

Sever pointed out that traction on the arm in adduction puts the upper cords of the plexus, which arise from the fifth and sixth cervical roots, under the greatest amount of tension, and causes them to stand out like bow strings. If the tension is aggravated, the cords are liable to be injured.

Thomas thinks that the paralysis is due to the inclusion of branches of the brachial plexus in the axillary inflammation which follows upon the joint injury.

Steindler holds that neither of these theories can be accepted to the entire exclusion of the other, and there seems to be no reason why gross lesions of the shoulder joint should not be combined in a number of cases with injuries to the nerve roots.

Varieties. There are three varieties of obstetrical paralysis

(1) *The upper arm type*, or the Erb Duchenne paralysis, which results, according to the supporters of the neurogenetic theory, from downward traction exerted on the arm. The shoulder is forcibly separated from the neck, beyond its normal limits, and the fifth and sixth cervical roots are consequently over stretched.

(2) *The lower arm*, or the Klumpke type, which is said to result

when the arm is pulled upwards above the head and the eighth cervical and first thoracic roots over stretched

(iii) *The whole arm type* where the exciting cause has been one of unusual severity and all the cords of the plexus have been to some extent involved. Sever found that in his series of cases the incidence of the three types was as follows: upper arm 400, whole arm 64 and mixed arm type 9.

CLINICAL FEATURES

Upper Arm Type Soon after birth the affected arm is seen to hang loosely at the side of the body; the forearm is pronated and the elbow slightly flexed while the child is unable to abduct the arm. For the first few days after birth some swelling or tenderness may be observed in the region of the deltoid but this usually subsides leaving a paralysis of the deltoid, supra spinatus, biceps, coraco brachialis and brachio radialis. Contractures soon develop from the unopposed action of the adductors and medial rotators of the shoulder.

In many cases the paralysis of the deltoid and supra spinatus is only temporary and with the repair of the injured nerve these muscles begin to function again. In the early stages therefore the greatest care must be taken to prevent the formation of adduction contractures. The cases in which the nerve lesion fails to heal and in which the muscle paralysis is permanent form a small minority. The typical course consists of a temporary paralysis followed by a permanent contracture. In some cases the contracture may even be complicated by subluxation or dislocation of the shoulder joint.

The Whole Arm Type In a small proportion of cases the lesion involves all the cords so that not only are the muscles of the shoulder affected but also those of the arm, the forearm and the hand. In these cases the paralysis of the intrinsic muscles of the hand together with that of the muscles of the shoulder is liable to persist. The lesion involves especially the fifth and sixth cervical roots and the ulnar and median nerves which are derived from the eighth cervical and first thoracic roots.

The Lower Arm Type In this type there may be at first paralysis of the whole arm followed by a quick recovery of the muscles of the upper arm, those supplied by the lower segment of the plexus remaining more or less permanently paralysed. The resulting paralysis is then of the inferior radicular group or Klumpke type.

In the whole arm and the lower arm types sensory disturbances are present. The anaesthesia is usually complete in the forearm and on the lateral side of the arm but the medial aspect of the arm is unaffected owing to the distribution of the intercosto brachial nerve. Frequently also in the inferior radicular type there are oculo pupillary signs—myosis, pupillary contraction and recession of the eyeball.

Sometimes associated are injuries in the region of the shoulder joint: fracture of the clavicle, separation of the upper humeral epiphysis.

physis and dislocation of the head of the humerus. Fracture of the clavicle greatly facilitates a rupture or tear of the plexus especially of the lower cords. The dislocation of the humerus is usually a posterior one although the anterior form has also been described.

The injury to the nerve roots is usually limited to the sheath but in some cases the roots may be completely torn across. When the sheath is injured the paralysis in the early stages is due to the resultant hæmorrhage and the œdema but later the formation of scar tissue may also play a part. The exact situation of the lesion is generally close to the point of exit of the roots from the vertebral column but in some cases the lesion is stated to have been actually within the canal.

PROGNOSIS

A minority of cases recover completely in three months and it is therefore impossible to determine clinically the exact extent of the lesion at an earlier date. In all cases of the upper arm type the prognosis is good but in the lower arm and whole arm forms the restoration of function is unlikely.

TREATMENT

Treatment should be instituted at the earliest possible moment as in the milder cases considerable improvement may be expected from conservative treatment alone.

If contracture is present in these earlier cases it will usually yield to simple stretching with or without anaesthesia. Thereafter the extremity is securely immobilized on a type of abduction splint with the arm abducted and rotated laterally the elbow flexed to a right angle the forearm supinated and the wrist dorsiflexed. The splint should be worn night and day and be removed only for purposes of massage and passive exercise. It is retained for at least six months after which the arm may be carried in a sling except that in lower arm types the wrist should still be kept in the dorsiflexed position by means of a cock up splint. The child as soon as he is old enough should be taught to play with toys or perform simple games so as to encourage voluntary movements of the affected muscles.

Cases with adduction contracture which will not yield to manipulation require an open operation for the relief of the deformity.

Sever's Operation. An incision is made from the acromion process downwards over the anterior aspect of the shoulder. The interval between the deltoid and the pectoralis major muscle is defined and these muscles retracted to either side. The upper part of the pectoral muscle is then divided at or near its tendinous insertion in order to give better access to the head of the humerus. The subscapularis tendon is then located as it swings round the head of the humerus to the great tuberosity. A blunt director is passed deep to it between it and the capsule and the tendon severed. The arm can now be completely laterally rotated. The muscles are allowed to fall

together, the wound is closed, and the arm is put up in plaster in abduction and lateral rotation for two weeks after which a splint is applied as previously described

Some authorities advocate osteotomy of the humerus with subsequent lateral rotation of the lower fragment Fairbank recommends that where abduction is incomplete the coraco humeral ligament close to the biceps and if necessary, the supra spinatus should be divided

The Repair of the Lesion The possibility of repairing the injured nerve roots is a matter of considerable uncertainty Theoretically exploration is indicated when there is no spontaneous return of muscle function but it is difficult to decide how long one is justified in waiting If however there is no improvement in 3 to 6 months exposure of the injured nerve roots would be indicated

The Exploratory Operation An incision is made along the posterior border of the sterno mastoid, the deep fascia is divided exposing the omohyoid and the transverse cervical vessels These vessels are ligated along with the transverse scapular artery and the thickened and adherent fascia divided to expose the plexus The lesion is generally found at the junction of the fifth and sixth roots which are usually enveloped in scar tissue The scar tissue is carefully excised with a sharp knife, and the nerve ends if completely divided should be brought together by sutures of fine linen thread which pass through only their sheaths After the wound is closed a plaster of Paris splint is applied which keeps the head and shoulders approximated to each other

In extensive lesions it may be necessary, in order to secure coaptation to divide the clavicle and the subclavian muscle If after this the shoulder is elevated and the head flexed towards the affected side, a gap of as much as 3 cms can be bridged

The Sciatic Nerve

The sciatic nerve may be injured in deep wounds of the thigh, especially gunshot wounds, while its peroneal branch may be implicated in comminuted fractures of the head of the fibula Since the nerve is very superficial at this point, it may also suffer in association with incised wounds of the same region

CLINICAL FEATURES

In a complete lesion of the sciatic nerve there is usually paralysis of all the muscles below the knee, but the hamstrings rarely suffer In partial injuries it is common to find the common peroneal motor syndrome predominating Sensation is abolished in the foot over a zone conveniently termed the 'shipper area' Ulceration frequently occurs from loss of trophic influences, the ulcers being usually under the fifth metatarsal head, on the sole of the foot, or the terminal phalanx of the great toe Such ulcers are very intractable—they perforate deeply, and infection and necrosis of bone often follow In partial

lesions the sensory phenomena are those of the irritation syndrome and after gunshot wounds a true caustalgia frequently develops

The Peroneal Nerve

The peroneal nerve supplies the tibialis anterior the extensor digitorum longus the extensor hallucis longus the extensor digitorum brevis and the long and short peroneal muscles Paresis of these muscles results in plantar flexion and inversion of the foot along with a certain degree of flattening of the long arch which is normally maintained to some extent by the tibialis anterior and the peroneus longus The patient walks with a high stepping gait the foot being elevated to allow the dropped toes to clear the ground

Anæsthesia is noted only over a small triangular area opposite the first metatarsal space



FIG. 263.—The Sciatic Nerve. The effects of a perforating ulcer of the foot are depicted as a result of a trophic disturbance in a case of sciatic paralysis.

The ulcer has penetrated to the fifth and fourth metatarsals parts of which have been eroded.

The Tibial Nerve

The tibial branch of the sciatic supplies the posterior muscles of the leg and all the plantar muscles so that when divided there is a complete inability both to plantar flex the foot and to flex the toes. Walking is not grossly interfered with by this paralysis and it may therefore easily pass unnoticed. The patient puts his foot down flat and does not lift the heel from the ground. He walks with a splay foot without spring or elasticity. The anæsthesia affects the sole and the dorsal surface of the lateral four toes and this lesion is more frequently than the peroneal followed by trophic disturbances—cyanosis of the foot hyperæsthesia and especially ulceration.

The healing of a trophic ulcer is often prevented by hard thickened skin around it. This obstructs the circulation so must be removed to allow the formation of granulation tissue. Accordingly excision is the best form of treatment.

CHAPTER XII

CIRCULATORY DISTURBANCES OF THE EXTREMITIES

Lesions of the peripheral vessels are an important and interesting cause of pain and fatigue in both the upper and lower extremities, and frequently require the attention of the orthopaedic surgeon. Recent advances in our knowledge of the structure and function of the autonomic nervous system, largely based on the results of surgical procedures in human subjects, have resulted in a clearer understanding of the mechanisms underlying many of the disturbances of the peripheral circulation.

The Circulation of the Extremities Since Claude Bernard first postulated the preservation of the "milieu interieure" as the determining factor in the freedom and independence of warm blooded animals, evidence has accumulated regarding the important part played by the peripheral circulation in the maintenance of the necessary constancy of internal conditions. The circulation of the extremities subserves such purely local functions as the transport of the metabolic requirements and products of the tissues, the production of an inflammatory defence in response to injury and the maintenance of local temperature at a suitable level. In addition it plays an important part in the regulation of body temperature. The surface area of the extremities is about 65 per cent of that of the whole body and as the limbs are usually lightly clad a large proportion of heat loss occurs from the skin of the limbs. The capacity of the vascular bed is greater than the total volume of blood contained therein, and therefore at all times active vaso-constriction must be present in a large part of the circulatory system to ensure that vital organs receive an adequate blood supply. Unusual demands for blood in one organ are met by local vaso dilatation or constriction in other parts of the body. The most common vaso constrictor stimulus is cold. Other factors which produce intense constriction in the extremities are fear, pain, anger, asphyxia, haemorrhage or dehydration. Such constriction may be so intense that the cutaneous circulation may temporarily cease. Vaso motor reactions are most intense in the extremities. The hand, wrist, foot and ankle are the regions most commonly affected by the factors listed above, and are also the parts most exposed to trauma and the influence of environmental changes. Constriction is most marked in the arterioles but also occurs in the capillaries and veins. The venous dilatation observed after sympathectomy is due at least in part to cessation of vaso-constriction.

The peripheral vessels are controlled by the autonomic nervous system. Preganglionic sympathetic neurones arise in the *intermedio-*

lateral column of the grey matter of the spinal cord from the first thoracic to the second or third lumbar segments, whence axons pass out in the anterior spinal roots, which they leave as a white ramus communicans to pass to the ganglionic sympathetic chain in which they run upwards or downwards to end around ganglion cells. Post ganglionic fibres pass from the chain in a grey ramus communicans to reach a spinal nerve and be distributed segmentally with the branches of that nerve to hair follicles, sweat glands and vessels. Other post ganglionic fibres run directly to form periarterial plexuses round the large arteries of the trunk, e.g. aorta, iliac, subclavian and carotid. Such plexuses pass into the limb for a short distance only, stopping just beyond the groin or the axilla. For the remainder of its course the artery is surrounded by a periarterial plexus derived from fibres which travel with the spinal nerves, and are distributed according to a segmental plan.

In the past much confusion has arisen because of the direct application of the results of sympathetic denervation in animals (cat and monkey) to the solution of problems in the human subject. By stimulation of the anterior spinal roots on the operating table it has been shown that in man the constrictor fibres to the arm arise in the third to the seventh thoracic segments (Foerster) those to the leg arise from the eleventh thoracic to the second or third lumbar segments.

According to Cannon any general stimulation of the sympathetic division of the autonomic nervous system causes a secretion of adrenaline which, widely distributed by the blood, has the same effect as the sympathetic impulses. It has since been shown that similar substances are set free by autonomic nerve impulses in or near the cells which they supply. In the case of the sympathetic this substance is known as sympathin (which is closely similar to, but not identical with, adrenaline) and of the parasympathetic it is probably acetylcholine.

It is generally believed that there is a chemical link between the electrical discharge which passes along the nerve fibres to its ending and the effector in the plain muscle supplied by that fibre. Dale has classified autonomic nerve endings as adrenergic or cholinergic according to the type of chemical link concerned, in the case of the limb vessels they are adrenergic. Certain of the sympathetic nerve endings are now known to be peculiar in that they are cholinergic.

When, following section, the nerve fibre degenerates, the sensitivity of the neuro effector mechanism is greatly increased and there is an exaggerated response to the appropriate chemical mediator. One of the functions of the chemical link is to reduce the number of nerve fibres necessary for the innervation of plain muscle. Incomplete denervation of a structure controlled by the autonomic nervous system results in little loss of function, since the chemical mediator diffuses from cells with an intact nerve supply to those which though denervated have become sensitized. In addition the denervated cells are unduly sensitive to circulating sympathin or adrenaline. This sensitization first appears about the eighth day after denervation and occurs only after

post-ganglionic section Following pre-ganglionic section there is a reduction in the sensitivity of the effector cells.

Knowledge of the vaso dilator mechanism is less complete The inability of the peripheral arteries of a limb to dilate further after sympathectomy may be evidence of the presence of sympathetic dilator fibres in the ramus divided It is believed that other dilator fibres exist in the posterior roots of the spinal nerves, having cell beds in the root ganglion, and that these fibres are part of an axon reflex and are stimulated by an impulse through the spinal sensory fibres The sympathetic dilator fibres are of chief importance and are concerned with the regulation of temperature

Sudomotor and pilomotor fibres are associated with those of vaso-constriction In the hands and feet there are numerous arterio venous anastomoses—the digital glomerular system of Popoff—by means of which in response to nerve impulses, the blood flow through the part, and hence the rate and amount of heat lost may be varied very rapidly For this reason amongst others, vaso spasm is more evident in the hands and feet than in other parts of the body Vaso constriction results in pallor and coldness and is associated with sweating Vaso-dilatation is followed by heat, redness, and dryness of the part

The Importance of the Capillary Area. The capillary area of the peripheral circulation is the site of the main physiological activity of the circulatory system Interchange of oxygen and carbon dioxide, and of nutritive and waste material, between the blood and the tissues takes place through the delicate endothelium of the capillary tubes Interference with the blood flow in this area is likely, therefore, to lead to profound changes in local tissue metabolism, temperature, and health

Classification of the Vascular Disturbances

An arbitrary division may be made between the disturbances which are chiefly of function, the *anatomy of the vessels remaining relatively normal* and those in which there are early organic changes It must be remembered that anatomical changes will be found in the late stages of the former and that often vasospasm is an important factor in the latter group

(A) *Primary Vaso motor Lesions*

- (1) Vasoconstrictor disturbances—Raynaud's disease
- (2) Vasodilator disturbances—Acrocyanosis, Erythromelalgia
- (3) Peripheral vasoneuropathy after chilling Immersion Foot and Immersion Hand

(B) *Primary Obliterative Lesions*

- (1) Mechanical—Embolism and thrombosis
- (2) Inflammatory—Thrombo-angitis obliterans
- (3) Degenerative—Arteriosclerosis

(A.) THE PRIMARY VASO-MOTOR LESIONS

(1) *Vaso constrictor Disturbances*

Raynaud's Disease

There is a tendency at present to discourage the use of the term "Raynaud's disease" on the grounds that it lacks specificity and includes a number of ill defined and different conditions. It is proposed to retain the term in this discussion, however, but to restrict it to a form of peripheral vascular disturbance usually affecting symmetrical areas of the hands and feet, characterized by intermittent pallor or cyanosis of the extremities and precipitated by exposure to cold or emotional disturbance. The smaller terminal arteries are constricted but the main vessels pulsate normally and, in the early stages, no pathological change occurs in the wall of the vessels.

Raynaud's disease is ten times more common in women than in men and usually occurs after puberty and before the menopause. Its effects are most marked in the exposed parts of the limbs. It is often symmetrical in distribution and may affect upper or lower, or all four extremities. Of the many individuals, mostly young emotional females, who suffer from "poor circulation," unusually cold moist hands and numbness of the fingers and toes on exposure to cold, the condition of the majority improves as they grow older but in some it progresses and may ultimately take the form of typical attacks of Raynaud's disease. Such an attack may be initiated by exposure to cold, by excitement or embarrassment. The first sign is pallor of the tips of the affected fingers, which may be followed by transient greyness as the remaining blood gives up its oxygen. In the early stages the pallor may be patchy and even intermittent but if the initiating factor continues to act spasm increases and the fingers appear more and more pallid, waxy and numb, and no fine movements can be carried out. Following relaxation of the spasm the circulation slowly returns to the fingers, their colour becomes bright red and capillary pulsation may be noticed. The fingers swell and tingle, and there may be an intense sensation of "pins and needles" or severe pain after a prolonged attack. These symptoms of returning circulation are most marked after rapid warming following a prolonged attack.

If these attacks continue their character changes. They are more readily provoked, and, starting in the tips of the fingers or toes, affect the whole of one or more digits and may continue into the palm or sole, even as high as the wrist or ankle. The colour is at first bluish, becoming slatey, and finally waxy if the spasm persists, patchy colour changes indicate incomplete or intermittent spasm, the colour variations being due to influx of fresh blood. Recovery occurs only following prolonged warming. As these more severe attacks become more frequent secondary changes appear in the digits, the pulp of the finger hardens, its skin becomes smooth and glistening, and the finger tapers towards the tip over which the nail curves. Small areas of thickened skin appear on

the finger tips especially under the nails, these plaques separate leaving small painful areas which heal very slowly. Ulceration infection or frank dry gangrene are uncommon but the pain may be so intense that the finger or even the hand becomes useless. These changes are usually more marked in the fingers than in the toes.

PATHOLOGY

According to Lewis there is an intermittent leakage of blood through the constricted arterioles during the stage of pallid asphyxia. The colour depends on the rate and amount of blood flow into the part and the temperature of the environment. The rate of dissociation of oxyhæmoglobin and tissue metabolism are markedly reduced at temperatures below 60 degrees Fahrenheit. Thus hands dipped in ice cold water may remain pink while at a higher temperature there may be marked vascular spasm combined with ready dissociation of oxyhæmoglobin resulting in cyanosis. Rapid warming by plunging the hand into warm water may result in abolition of spasm with an inrush of blood into anoxic tissues where increased metabolism and rapid dissociation of oxyhæmoglobin lead to deep cyanosis and the part turns black. These changes are often accompanied or followed by severe pain and patients soon learn not to use such methods.

It seems likely that the initial fault is in the autonomic nervous system when one considers that the disease is commonest in young emotional females is so frequently accompanied by excessive sweating and that changes in the vessel walls are the result of prolonged vaso motor disturbances. Lewis's claim that the disorder is due to a local hypersensitivity to cold does not explain adequately the response to pre ganglionic denervation and is probably a misconception due to observations made in advanced stages of the disease and following incomplete or post ganglionic denervation.

The late stages of Raynaud's disease are commonly associated with secondary changes particularly in the skin and subcutaneous tissues giving rise to the condition of scleroderma or sclerodactyly. At first the digits are swollen and firm and the skin is smooth (stage of oedema). Later they become stony hard and tense, and the skin is glistening and fixed and may appear varnished (stage of induration). Finally there is wasting and the skin becomes thinned and there may be brownish pigmentation (stage of atrophy). These changes have been recorded in the ears and nose. There is often associated ulceration and reduced growth of nails and hair.

(2) Vaso-dilator Disturbances

(a) Acrocyanosis

This condition most commonly affects the female sex and takes the form of a slow development of cyanosis or asphyxia of the hands and feet, generally as a result of exposure to a low temperature. The blue discolouration develops over a period of a day, or it may be several weeks. The fingers and the toes become cold, the movements of the

part are impaired and the finer adjustments of co-ordinated movements are sluggish and awkward. A peculiar hypæsthesia seems characteristic. This diminished sensibility does not appear to be of a hysterical nature although evidences of a general neurotic disposition are present. The cyanosis is often bilateral and in such cases roughly symmetrical although there may be slight differences in the intensity of the colour. As the attack passes off the part becomes warm and red and burning pain associated with œdematous swelling is experienced. These features gradually disappear and the part returns to normal. The condition is usually most severe in the hands probably because as a rule the feet are more adequately protected against low temperature.

Acrocyanosis resembles Raynaud's disease in its location but there is an absence of the blanching and other features of what is known as syncope. The absence of pain in acrocyanosis the fact that the attacks are progressive rather than paroxysmal and the increasing development of cyanosis are the usual distinguishing criteria.

PATHOLOGY

It has been pointed out by Lewis that the clinical picture of acrocyanosis resembles the changes which appear when the normal hand is subjected to a low temperature. He has suggested that the condition represents a peculiar sensitivity to the effects of cold on the cutaneous arterioles of those individuals who suffer from the disease. Thus a stimulus which would have little or no effect in the ordinary subject causes slowing of the cutaneous circulation due to arteriolar dilatation. This leads to anoxia capillary dilatation increased plasma outflow and therefore local swelling. The dilated capillaries packed with red corpuscles impart a deep red colour which becomes blue as the oxyhæmoglobin becomes reduced. the intensity of the colour depends on the quantity of blood contained in the part.

(b) Erythromelalgia

This condition was first described in 1878 by Weir Mitchell who believed it to be a rare vaso motor neurosis involving the extremities. It is characterized by redness burning pain and swelling of the hands and feet brought on by heat, exercise or the dependent position. During an attack the hands and feet become intensely cold and the skin acquires a bright red colour. When the parts are warmed a feeling of swelling fullness and throbbing is experienced. Burning pain may be induced by coll friction tension or elevation of the temperature of the limb to a certain critical temperature which varies with each individual. Pain is brought on by such a rise of temperature irrespective of whether the rise is due to the application of external heat or to increase in blood supply produced by other means. There may be great disability, the patient being unable to tolerate any covering or pressure on the affected part. The vessels are widely dilated and capillary pulsation is present. Lewis states that this condition is not of vaso motor origin since in normal subjects an equal degree of vaso

dilatation is not accompanied by pain. He believes that this disorder is due to a hypersensitivity of the pain fibres to heat or tension. Telford and Simmons have suggested sympathectomy in the treatment of this condition, arguing that the vessels of a sympathectomized limb are incapable of dilatation as well as of constriction. Following such operation pain is abolished and the circulation returns to normal.

(3) *Peripheral Vasoneuropathy after chilling*

Immersion Foot and Immersion Hand

These disturbances for which Ungley has recently suggested the alternative term of "peripheral vasoneuropathy after chilling," result from prolonged exposure to cold which is not so severe as to cause frost bite. Most subjects have been the survivors of shipwreck but the condition has followed exposure without immersion. When due to exposure in open life boats the most important causal factors are the duration of exposure and the temperature of the water, sea water at temperatures of 5° to 8° C may produce nerve damage in 22 hours (Ungley). Any factors which impair the circulation, such as constricting boots, socks or other clothing, immobility, chilling of the trunk, starvation or seasickness will increase the severity of the disturbance. Distinction should be made from frost bite in which the superficial tissues are frozen and the oedema without nerve lesions which follows prolonged immersion in sea water at higher temperatures (8° to 20° C).

There are three clinical stages. At first in the pre hyperæmic stage the cold swollen limbs are pale, mottled or blue in colour, numb and anæsthetic and pulsation is absent in the main vessels. After several hours the picture changes suddenly to that of the hyperæmic stage with pain, heat, redness, increased swelling and full vascular pulsation. The normal skin temperature gradient of the limb is abolished and procaine block produces slight if any rise in temperature. When the limb is horizontal the foot or hand is red; if dependent the colour becomes a deep purple and blanching rapidly follows elevation. In the more severe cases blisters appear after about three days, especially in areas which are to become gangrenous. Healing of blistered areas may take from one to six months. Pain, tingling, 'pins and needles' or burning appear early, may be very severe, and are made worse by warmth, cold, dependency and exercise. There is weakness and wasting of the muscles in the affected areas leading to later disturbances such as flat feet. Sweating, at first absent, later returns rapidly and may ultimately be excessive. The hyperæmic stage may last from a few hours or days up to three months. In the posthyperæmic stage inflammation subsides, vascular tone and skin temperature return to normal, but a state of cold sensitivity may develop in which, after cooling the limb, there are attacks of Raynaud's phenomenon or delay in warming in spite of attempts at reflex vasodilatation. A similar disturbance, the so called algid state, may occur during the latter part of the hyperæmic stage, both are probably due to partial interference with sympathetic innervation with sensitisation to adrenaline.

The lesions have been classified by Ungley into four grades according to their severity. Those with minimal lesions without interference with nerve function have swollen feet for a few days and transient tingling but symptoms subside within a week. Mild cases with reversible nerve lesions have symptoms for from three to six weeks with slight weakness of the intrinsic muscles of the feet, later there may be excessive sweating or cold sensitivity. Of moderately severe cases with severe (degenerative) nerve lesions 50 per cent. have blistering and a few superficial gangrene. anæsthesia extends nearly to the ankle joint, and muscle wasting is more marked. Symptoms may last for three months and functional return be delayed for six months. Very severe cases with irreversible (degenerative) nerve lesions usually with gangrene, have loss of sensation above the ankle, gangrene of the toes or distal half of the foot. infection may occur and amputation be necessary. Symptoms may last six months or more and late complications are frequent.

Early treatment follows the principle of cooling the affected limbs while warming the rest of the body. the affected areas must on no account be rubbed or heated. The limbs should be elevated and precautions taken against secondary infection of raw or gangrenous areas. The patient should remain in bed until all swelling has subsided and walking is painless. The late complications may be susceptible to sympathectomy.

(B) THE PRIMARY OBLITERATIVE DISTURBANCES

For the present purpose the most important of the organic or obliterative diseases of the arteries are arterio sclerosis and thrombo angitis obliterans. In these conditions clinical manifestations are much more common in the lower than in the upper extremities. The colour changes which supervene are produced by alterations in posture the toes becoming red when dependent and blanching when elevated. There may also be excessive fatigue after moderate exercise and the symptom of intermittent claudication is usually prominent. Pulsation in the main vessels of the extremity may be lost.

(1) Mechanical—Embolism and Thrombosis

When large peripheral vessels are occluded suddenly by injury or ligation there is a marked danger of the subsequent onset of gangrene, particularly in the leg where the collateral circulation is poorer than in the arm. Interruption of blood flow in a main vessel may be followed by generalized spasm of all the vessels distal to the obstruction, and if the collateral circulation is insufficient for the needs of the limb gangrene will follow. Diffuse spasm can be abolished and the collateral circulation improved by the interruption of the constrictor impulses as by paravertebral alcohol injection. When an injured or occluded artery is exposed at operation peri arterial stripping may be of benefit. In addition heparin is of value in cases of embolism or thrombosis. The development of an adequate collateral circulation may be hastened by intermittent vascular occlusion or passive vascular exercises.

(2) Inflammatory Thrombo-angitis Obliterans

The classical description of this disease was made by Buerger in 1908, and his name is still associated with the condition. Its incidence is high in the Jewish race, and it has been claimed that there is an association between it and excessive smoking. The disease affects males almost exclusively, most commonly those above the age of 30. This constitutes an important difference from Raynaud's disease with which it is liable to be confused in the early stages.

The symptoms usually begin with pain and cramp in the foot brought on by exercise and relieved by rest. These are succeeded by colour changes in the feet, redness or cyanosis, particularly when the limbs are dependent. Such colour changes are often associated with severe pain. When the limb is elevated it becomes pale and waxy. These are other features which are not found in Raynaud's disease. Trophic changes ultimately appear in the form of a localized superficial ulcer which will not heal, later dry gangrene may follow. In the severe late forms of the condition there is intense pain which is unrelieved by rest and may be so severe as to cause the patient to commit suicide.

PATHOLOGY

There is progressive obliteration of the large vessels of the lower limb, the veins being affected to a lesser extent than the arteries. The vessels are stiffened and hard, the adventitia is thickened, and the muscle fibres of the media are atrophied and infiltrated with connective tissue. The intimal endothelium proliferates actively, several layers of cells being formed. These changes are followed by thrombosis which is responsible for the occlusion of the vessels. Organization of the thrombus may be followed by some degree of recanalization, but in spite of this and the development of a collateral circulation, the blood supply to the distal parts of the limb is reduced. The disease is therefore in the nature of a chronic inflammatory condition of the vessels resulting in thrombosis. Buerger believed that the disease resulted from the effects of some specific infective or toxic agent, and this belief can be supported by a certain amount of evidence. An alternative explanation may be that the primary abnormality is a wide-spread spasm of the vessels as a result of some vaso motor disturbance, resulting in the constriction of the vasa vasorum, which, if sufficiently prolonged, produces the characteristic structural changes of the disease.

CLINICAL COURSE

Most cases follow a fairly typical course which is usually divided into stages. The first stage that of claudication is characterized by cramp like pain in the muscles of the calf and foot coming on during or after exercise. This stage is followed by or associated with colour changes, the extremities being red when dependent and pale when elevated. A new type of pain, entirely distinct from the pain of claudication, and more or less localized in the periphery, may then occur while the patient is at rest. In the final stage there are true trophic changes such as

fissures, ulcers, or frank gangrene associated with severe crippling and continuous pain. The total time of development of all these stages varies from one to ten years, the average time being five years.

The earliest symptom is usually aching from excessive fatigue after prolonged use of the muscles of the calf, the arch of the foot, the ankle or the knee. This is followed by cramp like pain during ordinary exercise and eventually by true claudication. The pain of claudication is not continuous but occurs when the weight of the body is thrown on the ball of the foot, and is relieved as the foot is carried forward.

Various theories have been advanced to explain its mechanism. The latest view is that the pain is not due to spasm of muscles or of vessels nor entirely due to anoxæmia but that there is produced a definite pain substance which in the normal individual is very rapidly destroyed.

Excessive redness of the extremities when they are in the dependent position may occur at any time but usually occurs soon after the claudication pain is established. At an early stage it affects the tips of the toes but gradually becomes more extensive involving progressively the toes the distal and then the proximal segments of the foot. The colour deepens from a bright pink to a deep red or slightly cyanotic hue and when fully developed is most intense in the toes and distal half of the foot.

In some cases disturbances other than claudication appear as the first evidences of arterial disease. These include cold feet, numbness or tingling, embosism, œdema, vaso motor disturbances such as pallor and coldness, recurrent phlebitis and indolent ulcers following slight trauma.

Embolism is usually indicated by a sharp pain at the point of impaction of the clot, and inspection shows extreme pallor and coldness distal to this point. There may be tenderness on pressure along the line of the affected artery. The pain subsides gradually and has usually disappeared in from 24 to 72 hours.

Superficial phlebitis occurs frequently the most common site being the main trunk of the internal saphenous vein below the knee, although the branches may also be affected. Inflammatory signs rarely persist for longer than 4 weeks in any one site, but when the condition spreads upwards along the vein the illness may last longer.

œdema from arterial disease is rare in the upper extremity but is common in the leg and foot particularly when the clinical course is rapid and when severe pain is felt during rest.

Vaso motor disturbances are often so marked as to mask the primary disease. The hands are more commonly affected than the feet, and the most striking change is complete pallor producing the so called dead finger. less striking are minor grades of pallor. cyanosis may also occur.

Rest pain varies greatly in severity but is constant in its situation being almost confined to the toes but occasionally affecting the dorsum of the foot or ankle. It precedes obvious trophic changes but is greatly accentuated by them when they appear.

The disease, then, is essentially slow in its progress. Characteristically, it affects relatively young individuals who at the start have an ample capacity for the development of a collateral circulation which permits recanalization of the thrombus. At its onset the disease is limited to a small segment of the vessels, so that the amount of recanalization demanded is small. As the attack subsides circulatory efficiency is re established, but there is a slight reduction in the available collateral supply. With each attack more and more of the main channels are occluded and more and more of the collateral channels are utilized, so that with each attack the margin of safety shrinks. Finally the total inflow of blood is barely enough to maintain life in the part, the demand for additional blood flow during exercise cannot be met, and ischaemic cramp (claudication) results, the hyperemia required for the healing of even minor wounds cannot be supplied, and indolent sores develop. The disease may take a more rapid course, attacks following so closely upon one another that healing practically never occurs. When it starts in older individuals, or is complicated by arterio sclerosis little or no collateral circulation develops and much slighter degrees of thrombo angustis may lead to gangrene. This disease is nearly always bilateral. Even when manifest in one leg only, it is almost certain to be latent in the other and sooner or later will give rise to signs and symptoms, and this feature must always be remembered when a prognosis and decision regarding treatment are being made.

(3) Degenerative—Arteriosclerosis

Arteriosclerotic vascular occlusion is an accompaniment of old age, and the patients are usually in poor general condition. The vascular involvement is not patchy as it is in Buerger's disease, but uniform so that when occlusion becomes manifest there are no entirely healthy alternative channels which can dilate to maintain the circulation. The margin of safety is therefore small. The process is slow and the duration of symptoms from the onset to the development of serious surgical situations necessitating amputation is very long except when occlusion is accelerated by infection or thrombosis. Apart from these accidents proper care may postpone the necessity for amputation by 5 or 10 years.

The process is predominantly degenerative rather than inflammatory or neuro-circulatory. In the muscular arteries of the extremities it begins as an increase in the mucinous metachromatic ground substance of the media for it is the media which carries the burden of functional strain in these vessels. As the mucin increases the elastic and muscle tissue of the media decrease, fat is deposited and hyalin fibro is sets in. This is soon followed by calcification which is found in 69 per cent of males and 21 per cent of females. The intima is involved first by fat deposit, then by proliferative changes. The patients generally do not have a high blood pressure. Those with a high blood pressure can usually keep on driving an adequate amount of blood through their thickened vessels, until one of the hypertensive accidents occurs.

DIFFERENTIAL DIAGNOSIS OF VASCULAR DISEASE AFFECTING THE EXTREMITIES

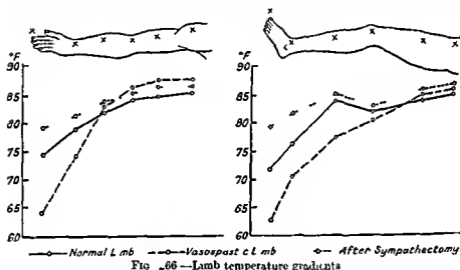
| | <i>Thrombo- arthritis obliterans</i> | <i>Artero- Sclerotic Disease</i> | <i>Raynaud's Disease and Similar Conditions</i> | <i>Pruritus Erythema metalgia</i> | <i>Acrocya- nosis</i> |
|---|--|--|---|---|--------------------------------|
| Pulsation of arteries | Pulseless 50 per cent Diminished 45 per cent Normal 5 per cent | Pulseless 50 per cent Diminished 45 per cent Normal 5 per cent | Normal | Normal | Normal |
| Excessive rubor with dependency | Present | Present | Absent | Present | Absent |
| Excessive pallor with elevation | Present | Present | Absent | Absent | Absent |
| Claudication | Usually present | Usually present | Absent | Absent | Absent |
| Gangrene | Common | Common | Rare | Never | Never |
| Rest pain | Usually very severe | Usually mild | Usually absent | Usually mild | Absent |
| Type of rest pain | Sharp stinging | Aching | Absent | Burning | Absent |
| Appearance of gangrenous ulcers | Moist in flamed, discharging | Usually dry | Small punched out areas | None | None |
| Superficial phlebitis | 30 per cent of cases | Absent | Absent | Absent | Absent |
| Age | Mostly between 25 and 45 years | Mostly between 55 and 85 years | Mostly between 18 and 30 years | Mostly between 30 and 50 years | Mostly between 30 and 50 years |
| Sex | Males 99 per cent | Males 90 per cent | Females 90 per cent | Females 70 per cent | Females 70 per cent |
| Colour changes following exposure to cold | 30 per cent | 15 20 per cent | Always | Always | Always |
| Oedema | Frequent | Infrequent | Absent | Absent | Present during attacks |

There is no significant difference between the lesions produced in the diabetic and non diabetic subjects. There is doubt as to whether vascular spasm is the initial factor giving rise to changes in the arterial wall, or whether spasm results from these changes. A significant degree of spasm is found in a proportion of patients, especially in the earlier stages. Pain is a prominent symptom, largely because of the severe degree of circulatory insufficiency and alone may be sufficient indication for amputation. The blood supply may be worse in a painful though non gangrenous leg than when gangrene is actually present

Methods of Investigation

According to White and Smithwick the three fundamental essentials for the investigation of disorders of the peripheral circulation are 1. a room the temperature of which can be maintained constant within 2 degrees Fahrenheit for two hours at any season of the year an accurate apparatus for the measurement of skin temperature and a familiarity with methods of producing temporary inhibition of sympathetic activity

Slight fluctuations in room temperature exert a significant effect on peripheral surface temperature humidity changes are of less importance An operating theatre is suitable provided that the temperature and humidity can be accurately controlled In making observations for comparison such a room is essential and the tests should be carried out at similar hours of the day and under basal conditions Tests are



of no value if done on very hot days in the presence of fever or of cachexia due to advanced malignant disease. The temperatures at comparable points on opposite limbs of a subject with normal arteries do not commonly differ by more than 2 degrees and it is thus possible to use one side as a control when testing the other side. In normal subjects the skin temperature is constant from the trunk to the elbow or knee and then falls as the tips of the fingers or toes are approached (Coller and Maddock). When vasospasm is present the fall is more marked from the middle of the forearm or calf than in the normal limb and the toes or fingers may be cooler than the environment. Following paralysis of sympathetic nerves this fall is abolished and the temperature is constant over the whole limb. The average maximum dilator response of undiseased arteries has been described as the normal vaso dilatation level (Morton and Scott) the lower limit of which following complete constrictor release by regional or general anaesthesia or heating of the body is 86.0 degrees Fahrenheit. Accurate estimations of the skin temperatures before and during temporary blockage of sympathetic

impulses (as by procaine) demonstrate the degree to which the skin temperature approaches the normal vasodilatation level after blockage. This provides an indication of the benefit which is likely to result from sympathectomy and should be carried out in all cases. A convenient method of measuring skin temperature is by means of a differential thermocouple using copper constantan junctions such as that made by the Cambridge Instrument Co. A self recording type is also on the market.

Sympathetic constrictor control may be abolished by the following methods

(1) *Heat* Lewis and Pickering have described a chamber in which the patient's body can be heated and from which the arms and hands protrude. Alternatively the body can be heated by a large shock cradle (White and Smithwick) or a single extremity can be heated by immersion in a water bath heated by an electric element (Gibbon and Laodis).

(2) *Diagnostic procaine block* This method is based on the demonstration that sympathetic vaso motor fibres could be blocked temporarily by procaine either by spinal anaesthesia (paralysing the pre ganglionic fibres in the anterior spinal roots) by paravertebral block (sympathetic ganglia and runi communicantes) or by peripheral nerve block (post ganglionic fibres in the mixed nerves). Any of these methods provides a quantitative demonstration of the amount of benefit which will be derived from sympathectomy. A description of the technique of paravertebral block will be given later.

The use of general anaesthesia, typhoid vaccine and similar procedures are of less value than the above and are more disturbing and unpleasant to the patient and should be discontinued.

The actual level of main vascular obstruction can be estimated by palpation of the vessels. The dorsalis pedis, posterior tibial, popliteal and femoral should be palpated in turn. The difficulty of this test sign however is that the pulsations of the main vessels are accessible for palpation at only a few widely separated points near the larger joints. To obviate this difficulty and to obtain a more accurate and readily measured estimate of vascular pulsation the Pachon oscillogram was devised. This may be applied at any segment of the limb and the total vascular pulsation of that segment under varying external pressures determined and compared with the other limb or with the normal. At the level of main vascular occlusion there is a decrease in the pulsation volume. In a part of the limb where there are two fairly large vessels if one is occluded the other may dilate sufficiently in compensation for the normal pulsation volume to be maintained. For this reason the Pachon oscillogram does not determine the exact level of occlusion; it merely determines the level of pulsatile collateral supply. Beyond this level there is a slow non pulsatile collateral supply which the machine does not register.

Normal arteries cast no shadow on the X ray film. Only the main vessels of the arterio sclerotic limb can be directly visualized. The

arterial tree can be demonstrated by injecting some opaque substance into the main vessel in the proximal part of the limb. Thorotrast has been recommended by Allen and Camp (10 to 20 c c for the leg, 5 to 10 c c for the arm), but this agent has not been widely used on account of its radioactivity. 20 c c of a 40 per cent solution of Perabrodil Forte, which is free from the objection to Thorotrast, has been used by the author without ill effect. It is commonly recommended that blind arterial puncture be performed, but exposure of the vessel under local anaesthesia is easily carried out and is more accurate. The vessel is compressed proximally during the injection and a film is taken after momentary release of compression. The method is of use in localizing the level of blockage of a vessel and gives valuable information regarding the collateral circulation.

It is sometimes necessary to test the vaso motor responses after sympathectomy to show that denervation is complete or to detect regeneration. Any of the methods already described for inhibiting constriction or producing dilatation by heat or procaine block may be used. the most convenient is peripheral nerve block. In addition the presence or absence of sweating may be demonstrated by the starch-iodine test of Victor Minor. 10 c c of castor oil are added to 90 c c of 15 per cent tincture of iodine and the mixture is painted on to the skin and allowed to dry. Starch powder is then insufflated on to the skin and adheres to the castor oil. Wherever moisture appears a deep blue black colour develops. Instead of the starch iodine method Quinizarin Compound may be used in powder form which is dusted on to the skin, a purple colour appearing in the areas in which sweating occurs.

TREATMENT OF PERIPHERAL VASCULAR DISEASE

The treatment to be adopted in any individual case of peripheral vascular disease forms one of the most difficult of surgical problems. The therapeutic measures available are

- (1) Local and general measures to improve the peripheral circulation
- (2) Sympathetic denervation
- (3) Peripheral nerve section
- (4) Amputation

1 LOCAL AND GENERAL MEASURES TO IMPROVE THE PERIPHERAL CIRCULATION

The broad principles of the treatment of early peripheral vascular disturbances may be stated shortly as the prevention or abolition of vaso-spasm where this is present combined with the protection of areas with an impoverished blood supply from trauma of all kinds. In the later stages, palliative procedures designed to relieve pain, and amputation may be necessary.

Such patients present a dual problem in treatment—that of improving their general condition and the treatment of the local disorder. Each

patient requires careful investigation and treatment as an individual. Attention should first be directed towards the improvement of their general condition before passing to the more radical procedures designed to correct local disturbances.

A period of complete rest in bed is always beneficial but should not be prolonged as this may result in undue loss of mobility in elderly subjects. Draughts should be carefully excluded. The value of adequate sound sleep is very great and this should be ensured by suitable sedatives. Vaso dilatation is marked during sleep and persists for some time after waking if the extremities are kept warm. For this reason many of these patients immerse their unaffected extremities in hot water on rising which produces a lasting vaso dilatation especially if combined with warm gloves and socks. There is no doubt that excessive smoking has an adverse effect on peripheral vascular disturbances and in many subjects even slight indulgence is followed by an evident increase of spasm. It seems wise to cut down smoking as much as possible. Alcohol, by producing vaso dilatation, is of benefit but subsequent excessive cooling may result in intense spasm and alcoholic drinks should be consumed only in warm surroundings or before going to bed. Such measures as active and passive exercises, dry heat and hot baths may be employed to improve collateral circulation. In Buerger's exercises the patient lies on his back and raises the limb to an angle of 60 degrees with the horizontal for 3 minutes then lowers it to hang in a vertical position for 3 minutes and finally it is raised to the horizontal for 5 minutes. The cycle is then repeated. By means of the Pævex apparatus the pressure in a chamber into which the limb is inserted is varied rhythmically, alternating negative and positive pressure to a degree and rate which are selected according to the condition of the limb. The injection of antispasmodic drugs is of no value in the treatment of peripheral vascular disturbances. Similarly the use of T A B vaccine or Typhoid H antigen are useless. Syphilis, diabetes, or bad teeth should be treated by suitable measures.

General Directions for Patients suffering from Vascular Disturbances of the Feet In addition to the above great care must be taken of the affected part and the following rules will be found invaluable. The feet should be washed each night with warm water and soap and dried with a soft towel. Methylated spirit should be applied and allowed to dry after which the skin may be anointed gently with hydrous lanolin to keep the skin soft, supple and free from scales. The feet should always be kept warm. Woollen socks or wool lined shoes in the winter and cotton socks in warm weather are satisfactory, and where possible a fresh pair of socks should be used each day. Loose fitting bed socks should be used in preference to hot-water bottles or other mechanical heating devices. Walking shoes should be loosely fitting and of soft leather. Very great care should be exercised when the toe nails, corns or callous skin are being cut and if the nails are dry and brittle they should be softened in warm

water nightly and linoline generously applied on, about and under the nail. Circular garters and strong antiseptic drugs should both be avoided. The appearance of blisters on the feet should be the signal for careful treatment. The blisters should be snipped the skin removed and a dry dressing applied. Regular exercises, short of fatigue should be prescribed. The extremities should be carefully protected from trauma since mild abrasions frequently initiate gangrene. The patient should be warned of the danger of injury to his extremities and the reasons for the precautions enjoined should be explained to him in order to secure his co operation.

2 SYMPATHETIC DENERVATION IN VASCULAR LESIONS OF THE EXTREMITIES

In the treatment of vascular disturbances of the extremities sympathetic denervation is of value only where vaso-spasm can be demonstrated by one of the methods already described. The beneficial effect of such denervation will be in direct proportion to the amount of spasm present provided that a suitable complete pre ganglionic denervation be carried out. In addition such denervation is of undoubted value in an attempt to improve the circulation in a limb affected by obliterative vascular disease when spasm is present.

It is generally believed that thrombo angitis obliterans tends to run a chronic course for a varying period, after which the progress of the disease is arrested and healing occurs. If gangrene and amputation can be avoided during the active stage an adequate collateral circulation may develop and function may be restored. This process may be greatly assisted by the removal of reflex vaso spasm by a suitable sympathetic denervation. Sympathectomy is of little value if pulsation is absent in the proximal main vessels.

Vaso spasm is a common accompaniment of arterio-sclerotic occlusion of the vessels of elderly subjects and is frequently the factor which precipitates gangrene. The extent of such gangrene may be limited and collateral channels more widely opened by removal of vascular spasm by denervation. In the same way it is often possible to delay amputation in one or more limbs for a considerable period. The circulation to the skin and subcutaneous tissue and muscle may be improved and claudication may be reduced or abolished by sympathectomy. In the majority of cases improvement should first be demonstrated by a suitable test, in a minority it has been shown that operation is of value in spite of the absence of a favourable response to testing.

The discolouration and coldness of the legs associated with anterior poliomyelitis are usually due to vaso spasm and if a suitable response be obtained to diagnostic spinal block improvement will follow lumbar ganglionectomy. ulcers may heal and the skin temperature rise.

There is general agreement that periaarterial sympathectomy as advocated by Leriche is of little value in the treatment of disorders of the peripheral vessels. The procedures in common use are diagnostic

and therapeutic paravertebral injection of sympathetic ramus and ganglia, and thoracic and lumbar sympathectomy

Paravertebral Injection Blockage of the sympathetic trunks and ganglia by the paravertebral injection of anæsthetic drugs is a procedure of great value, since by this means it is possible to obtain an accurate estimate of the effect on the peripheral circulation of removal or destruction of these ganglia. The therapeutic value of this method is no less great in properly selected cases. A single injection of local anæsthetic may produce much relief in conditions such as traumatic arthritis or causalgia. Alcohol injection is of value in producing sympathetic denervation in subjects unfit for operation but it must not be used as a substitute for operation in subjects fit for this. Accurate injection is difficult and may be followed by traumatic neuritis of intercostal nerves. General anæsthesia cannot be employed during paravertebral injection but phenobarbitone or morphine and byoscine should be administered to allay anxiety. The spinous processes of the thoracic vertebrae are opposite the transverse process of the vertebra below. Under local anæsthesia long needles (spinal puncture needles are suitable) are inserted 4 cm from the midline at the level of the upper three ribs, until the needle hits the rib. The needle is manipulated until it passes below the lower border of the rib then rotated laterally through 20 degrees and pushed in for a further 3 cm. Contact should be made with the side of the vertebral body at this point. If it is missed the needle should be directed more towards the midline. If contact is made sooner the needle should be reinserted at a slightly less angle. A test aspiration should now be made to ensure that the needle has not entered the pleural or subarachnoid space or a blood vessel. This latter is common in the case of the upper two ribs. When all the needles are in position 5 c.c. of 1 per cent procaine solution is injected slowly through each needle. Signs of sympathetic paralysis should develop within ten minutes, the arm, hand, face and neck should become hot and dry, but there should be no anæsthesia in these areas. If this does not happen within ten minutes the needles should be withdrawn and a further attempt made later. If a satisfactory paralysis develops and it is desired to inject alcohol, 5 c.c. of 95 per cent alcohol is injected slowly through each needle. Pain should be abolished by the preliminary injection of procaine but if it develops the injection should be stopped until it passes off. The site of injection can be marked by injecting a few drops of lipodol into each needle after the alcohol. The needles are then withdrawn and the patient is turned on his back to lie quietly in that position for at least half an hour. He may then return to bed for 24 hours.

In the case of the lumbar gangliated chain the needles are inserted 3 cm lateral to the upper border of the spinous processes of the third, fourth and fifth lumbar vertebrae. Each needle is pushed in 3 to 4 cm at which point contact is made with the transverse process. The needle is passed over the upper edge of the transverse process and the tip turned slightly medially and thrust through the psoas muscle until

it hits the vertebral body. The syringe is fitted to each needle in turn and aspirated. Procaine is then injected through each needle and sympathetic paralysis is shown by warmth and dryness of the foot and leg of the same side

Thoracic Sympathectomy

(a) Posterior approach Prior to operation the spinous process of the second thoracic vertebra is identified under the fluoroscopic screen and is marked by scratching the skin. The patient lies in the prone position with the chest supported on a pillow so that the shoulders and arms fall forwards and the head is supported on a small pillow

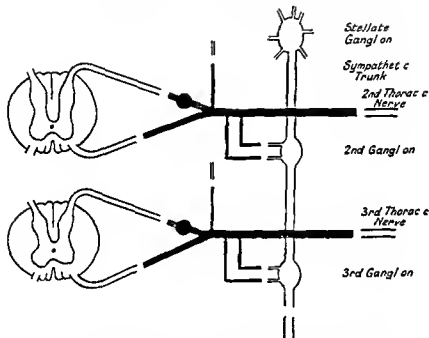


FIG. 267.—Diagram to show sites of section for upper limb sympathectomy (intra spinal section). Black indicates tissue excised.

so that the neck is slightly flexed. Intratracheal nitrous oxide-oxygen ether anaesthesia is employed. An incision is made four inches in length two inches from the mid line centred on the second thoracic spinous process. The fibres of the trapezius are divided in the line of the skin incision, the fibres of the rhomboid muscle are split, its deep surface is separated from the underlying structures and the third rib is identified. This rib is exposed by dividing and elevating the paravertebral muscles and the inner two inches of the rib and the distal inch of the vertebral transverse process are excised subperiosteally. The pleura is separated by blunt dissection to the mid line and upwards and downwards for two inches exposing the second and third intercostal nerves and the sympathetic trunk. One of three procedures may now be carried out (Smithwick)—

(1) INTRASPINAL ROOT SECTION The third intercostal nerve is divided at the lateral margin of the incision, the proximal end raised from its bed and its rami communicantes and dorsal branch are cut. The anterior and posterior roots are then exposed and separated and the posterior root divided just proximal to its ganglion. The meninges are pushed medially along the anterior root until the glistening intradural part is seen the root is divided at that point the proximal end retracting within the arachnoid.

(2) EXTRASPINAL ROOT SECTION The roots of the nerve are divided just proximal to the posterior root ganglion and the rami communicantes are cut as above.

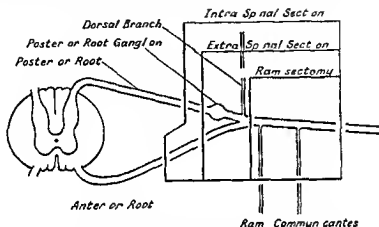


FIG. 268 --Types of Nerve Section

(3) RAMISECTOMY The intercostal nerve is divided lateral to the posterior root ganglion the rami communicantes are cut as above.

Ramsectomy is the easiest and intraspinal section the most certain of the three methods. The second nerve is similarly dealt with and the sympathetic trunk is divided below the third thoracic ganglion and the upper end of the trunk is brought out of the thorax ligated and sutured into the paravertebral muscles. Smithwick advises that the upper end of the trunk be enclosed in a silk cylinder in order to prevent regeneration. The wound is closed in layers with interrupted sutures without drainage.

(b) Anterior approach The patient lies on his back with a firm sand pillow behind his shoulders to extend the cervico thoracic spine and his head is rotated towards the opposite side. Intratracheal nitrous oxide oxygen ether anaesthesia is employed. A transverse incision is made a finger's breadth above the clavicle, passing laterally for three inches from the inner border of the sterno mastoid muscle. The external jugular vein is divided between ligatures, and the clavicular head of the sterno mastoid is divided to expose the scalenus anterior muscle. The phrenic nerve is raised from the anterior surface of this muscle freed and retracted medially with a small blunt copper spatula which also draws away the carotid sheath and internal jugular vein. A dis

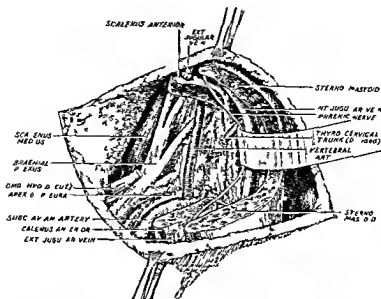


FIG 269—The anterior approach to the Stellate Ganglion

The anatomical area shown is wider than that actually seen at operation but given in this way a better orientation for the operator

sector is passed beneath the scalenus anterior which is now divided close to its insertion to expose the subclavian artery. The vertebral artery and thyro cervical trunk are defined and the latter is divided between ligatures. On the left side the thoracic duct may now be exposed and should be gently retracted medially. The subclavian artery is drawn forwards and downwards and the costal attachment

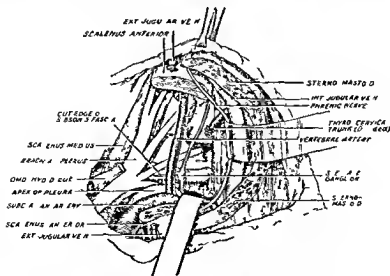


FIG 270—The anterior approach to the Stellate Ganglion

Sibson's fascia has been divided from the first rib and the ganglion exposed after retraction of the apex of the pleura

of Sibson's fascia is incised along the inner border of the first rib. The apical pleura is thereby exposed and may be stripped forwards and downwards by blunt dissection to the level of the third rib and held by a flat illuminated retractor. The cervico thoracic (stellate) ganglion can now readily be seen lying on the head of the first rib, with the trunk running downwards from its lower pole and a number of fine rami passing out from its upper pole. The trunk is followed down to the third ganglion below which it is hooked up and divided. The upper cut end is then grasped in fine forceps and drawn upwards the white and gray rami communicantes of the second and third ganglia being divided. During the exposure and definition of the trunk troublesome bleeding may occur from the branches of the superior intercostal vein and artery. This may be controlled by the application of Cushing's clips. The upper cut end of the trunk should be drawn into the wound and sutured to muscle to prevent regeneration. The stump may also be enclosed in a silk cylinder as advocated by Smithwick. This procedure interrupts all vaso constrictor and sudomotor fibres to the arm and head but does not affect the oculo pupillary fibres. The wound is closed in layers without drainage the cut edges of the sterno mastoid and platysma being sutured.

Lumbar Ganglionectomy

The lumbar gangliated chain may be exposed by the trans peritoneal or extra peritoneal routes. The trans peritoneal route has certain advantages when it is desired to deal with both sides at one operation. When operating on one side only or on both sides on different occasions the extra peritoneal route is preferable since by this method excellent access is obtained with little disturbance to the patient. Both approaches will be described.

(a) Trans peritoneal approach High spinal block is the anæsthetic of choice and the patient is placed in a modified Trendelenburg position. The abdomen is opened through a lower paramedian or mid line incision and the intestines are packed into the upper abdomen.

LEFT SIDE The parietal peritoneum is incised lateral to the pelvic and descending parts of the colon, which are mobilized medially by blunt dissection. The ureter adheres to the colon and peritoneum and is mobilized with them. The colon is held away by a retractor and the aorta and left common iliac artery are exposed. The genito femoral nerve is seen running down the surface of the psoas muscle. The sympathetic chain lies rather deeply in the groove between the aorta and the bodies of the lumbar vertebrae medially and the psoas muscle laterally and may be embedded in fat and surrounded by lymphatic glands which make its identification difficult. The chain is most easily identified at its lower end where it passes behind the left common iliac artery and is divided above the fourth lumbar ganglion which usually lies behind that artery. The chain is now defined by blunt dissection with small wool pledgets on forceps and as its rami are found they are cut with scissors until the chain has been freed to

a point above the second lumbar ganglion where it is again cut across

RIGHT SIDE The peritoneal incision is made just lateral to the inferior vena cava and is carried downwards over the right iliac vein. The ureter and cæcum are retracted laterally and the veins are retracted medially with a blunt copper spatula. The chain lies more behind the vena cava on the right side than the aorta on the left side, and passes beneath the common iliac vein below.

The dissection of the trunk is more difficult on the right side because of the thinness of the vena cava and the presence of the lumbar veins which may pass either superficial or deep to the trunk and if torn give rise to troublesome bleeding. On the left side there may be similar difficulty at the lower end of the chain. Such bleeding is best controlled with Cushing's clips. The peritoneal incisions are closed with catgut before the packs are removed and the abdomen is closed.

(b) Retroperitoneal approach Spinal block is the anæsthetic of choice. The patient is placed on his side with a sand bag under the loin. The lower limb is flexed to a right angle at the hip and the upper to half this extent. A pillow is placed between the thighs and the patient is tilted slightly towards the operator and this position is maintained by sand bags behind the thighs. An incision is made from the angle between the twelfth rib and the sacro spinalis muscle downwards and forwards parallel to the rib and continued until it reaches a point above and about one inch from the anterior superior iliac spine. The posterior fibres of the external oblique muscle are divided in the line of the skin incision to expose the internal oblique muscle and its attachment to the lumbo-dorsal fascia. These structures are divided in a line parallel to the twelfth rib from the border of the sacro spinalis behind to the origin of the transversus in front care being taken to avoid the subcostal and ilio inguinal nerves which lie respectively above and below the line of this incision. By blunt dissection the peritoneum is mobilized forwards from the quadratus lumborum and psoas muscles, from the lower pole of the kidney downwards. The ureter is mobilized with the peritoneum. The sympathetic trunk may be palpated on the anterolateral aspect of the vertebral bodies at the medial border of the psoas muscle. The peritoneum and ureter are retracted forwards with a large curved illuminator retractor and the trunk and its second and third rami are now easily exposed. The lower end of the trunk is cut across below the third ganglion and lifted up and the rami to the second and third ganglia are divided and the trunk again cut across above the second ganglion. Bleeding may occur from the lumbar veins during the dissection of the trunk especially on the right side where the vena cava is in close relationship to the trunk and must be retracted gently to facilitate exposure of the trunk. The wound is closed in layers with catgut sutures without drainage.

(3) PERIPHERAL NERVE SECTION

The severe pain of thrombo angitis obliterans and arterio sclerosis may be so bad as to make the patient's life a misery. The pain of dressing ulcerated or gangrenous areas is an additional trial. Peripheral nerve section interrupts not only sensory but also sympathetic fibres and is in effect a localized sympathectomy. it thus produces symptomatic relief and a localized abolition of vaso spasm with improvement in the circulation. Laskey and Silbert first advised alcohol injection of the nerves exposed under local anæsthesia but as this method frequently resulted in delayed healing or ulceration they later suggested section and immediate suture of the nerves. Smithwick and White have found the simpler procedure of crushing the nerves equally effective.

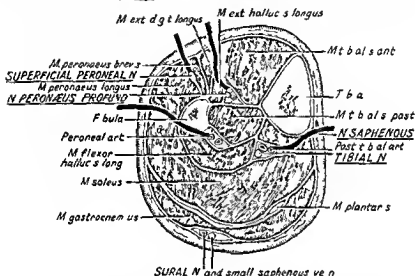


FIG 271—Section through the leg four inches above the ankle to show position of nerves that may be sectioned

In order to ensure good healing accurate anatomical exposure with a minimum of trauma is essential and the skin only should be loosely sutured. Regeneration of the nerve takes from three to six months. Scrupulous care should be taken of the anæsthetic areas which should be protected from trauma. If sufficient improvement results from this operation it may be possible to carry out local treatment of ulcerated or gangrenous areas and lumbar ganglionectomy should be considered as an additional measure to delay amputation.

(4) AMPUTATION

Amputation is most commonly called for in obliterative disturbances affecting the legs. The digits are supplied by end arteries and their collateral circulation is poor. Conservative treatment should always be tried when gangrene is localized to one toe and there is a good line of demarcation. Absence of lymphangitis, cellulitis and osteomyelitis and no generalized toxæmia. Early amputation of a single toe is

dangerous and often results in a further spread of gangrene, and healing is usually delayed. The patient is put to bed with the affected part covered with a light dry gauze dressing and protected by a simple wire cage. A thermostatically controlled heated cradle is placed over one of the other extremities and prophylactic doses of gas gangrene and tetanus antitoxic sera are injected intramuscularly. In the presence of mild local infection a localized debridement of the gangrenous area should be carried out as a preliminary step to lessen toxæmia and lower the temperature and pulse rate. In such cases it may be permissible to wait for local healing where the first step has been a limited procedure. But if it has been at all extensive amputation should be carried out as soon as the patient's condition permits. In diabetic gangrene inability to control glycosuria even with large doses of insulin is an indication for immediate amputation following which control of the diabetes is usually readily effected. When a limb is useless intractably painful or endangering life amputation is indicated. Amputations through the foot or ankle regions are seldom successful. If it is doubtful whether a good below knee stump five to six inches in length can be obtained amputation through the lower third of the thigh should be carried out.

Summary of Treatment

It is important to recognize that a disturbance such as Raynaud's phenomenon may result from several combinations of the same factors. It is essential in the case of a particular patient to assess the relative importance of the factors concerned before it is possible to decide the most suitable form of treatment. For each individual there is a critical temperature below which vaso spasm occurs. The higher the temperature the more severe and disabling is the disease. Recovery from an attack is correspondingly slower and changes in the vessel walls are usually more marked. In most cases some improvement will follow the wearing of warm woollen socks and gloves and the avoidance of extreme cold. In the early stages where there are no detectable changes in the vessels or soft tissues and full vaso dilatation follows heating the results of pre ganglionic sympathetic denervation are excellent. Where there are slight changes in the digits and reflex vaso dilatation is slow and incomplete the progress of the disease may be arrested and the frequency and severity of the attacks reduced by pre ganglionic denervation. Where the disease is in an advanced stage and there is little local reflex response to heating other parts of the body pre ganglionic denervation is useless since any response is slight and usually transitory. If a lower limb is affected the second and third lumbar ganglia and intervening trunk are removed (in females the first may also be included). In the case of the upper limb the trunk is divided below the third thoracic ganglia and all the ram to and from the second and third ganglia are divided. In acrocyanosis and erythromelalgia similar treatment to that detailed above for Raynaud's disease is indicated.

In the obliterative disturbances thrombo angutis and arterio sclerosis the problem is rather more complicated. General treatment is of great importance, but in addition it is essential to estimate the degree of vascular efficiency of the affected limbs and the part played by vaso spasm. The site and extent of arterial occlusion and the potential and actual collateral compensation must also be assessed. Age is important in considering the potential collateral circulation which diminishes with increasing age and in the obliterative disease. The colour temperature and the state of nutrition are valuable criteria. In the presence of gangrene a sharp line of demarcation indicates good collateral circulation in the unaffected part, provided infection is not present. Skin temperatures taken at intervals along the length of the limb may show an abrupt fall beyond the site of vascular occlusion. Simple palpation of the main vessels where these are accessible provides a certain amount of information but more accurate knowledge may be gained from oscillometry. The reflex vascular response to heating another extremity must be estimated and on the result of this test depends the decision as to whether sympathetic denervation will be of value. Unless marked improvement results from rest in bed abstinence from tobacco and a diet containing a high content of calcium and little potassium, sympathetic denervation should be advised when the patient is under 40 years of age, there is a good dilator response to heating and no evidence of involvement of vessels other than those supplying the limbs. This operation should be urged upon those patients who have already lost one or more limbs or parts of a limb or who have no pulsation in their main vessels at the level of the wrist or ankle since following operation mobility and the use of the fingers are greatly increased. The disease can and does progress following operation and conservative treatment must be continued. Passive vascular exercises are then of greater value since hyperæmia may be more readily induced. Subsequent thrombosis is not followed by a massive constrictor response as the reflex arc is interrupted by the operation. Where there is no reflex response to heating the operation is of little permanent value but paravertebral injection of alcohol may produce a temporary improvement of some months duration. Peripheral nerve crushing should be carried out to relieve intractable pain. Later amputation may be necessary.

Arterio sclerosis may be associated with a sufficient degree of vaso spasm to justify sympathetic denervation. Where this is so operation is often followed by an improvement in the nutrition of the skin and subcutaneous tissues and claudication may be lessened. There is usually practically no spastic element in the type associated with diabetes.

CHAPTER XIII

AFFECTIONS OF THE SPINE

LOW BACK PAIN

The variable character of low back pain its multiplicity of causes and the difficulties in its treatment render this affection one of the most difficult as also one of the most frequent problems that confront an orthopaedic surgeon. Moreover the condition has important industrial and economic aspects and in this connection the advice of the surgeon is often sought. Many individuals habitually assume at work or otherwise positions of great mechanical disability and sooner or later under the stress and strain the body tissues rebel and backache results. Industry both heavy and light therefore suffers a severe drain on its man power from this type of affection since slight traumata may throw on the disabled list for very long periods those whose bodies have been repeatedly insulted by postural errors, and the consequent mechanical strain. Perhaps the most important feature of this type of affection is the great uncertainty of diagnosis and to this fact may be attributed the improper treatment that has been meted out in the past.

In dealing with cases of low backache it is essential to have a comprehensive method of investigation. A systematic and routine examination must include all possibilities otherwise little progress can be made either in the diagnosis or the treatment. The orthopaedic surgeon should have for each patient a blank questionnaire which should be carefully and methodically completed.

The Complaint Low back pain may take the form of a dull heavy sensation which annoys and depresses the patient or it may be a sharp agonizing pain from which only sedatives give any relief. In addition to the pain there may be stiffness in the back. There is nothing particularly characteristic in either of the two complaints but the pain and its salient features must be thoroughly investigated.

The Pain

(a) *The Situation* The situation of the pain is a fairly good index of the site of the causative lesion.

(b) *The Reference* The pain may be referred to a variety of regions. In lumbosacral strain it is usually reflected to the calf and the foot. In sacroiliac cases it may be experienced in the posterior aspect of the thigh and may also be referred to the sciatic notch and to other parts of the leg.

(c) *The Duration* It is important to know how long the pain has been present and so determine whether the condition is acute or chronic

(d) *The Mode of Onset* It is essential to know how the condition started and particularly whether trauma preceded its onset

If there is a history of anything in the nature of an accident a careful statement should be obtained and certain questions are of great importance in this connection Was there a direct injury to the part or was there a twisting form of violence liable to cause a strain or sprain of some of the joints? Does the history fit in with a diagnosis of a ruptured muscle or of certain fibres of a muscle or of ligaments? It should be recalled that unilateral leverage through the hamstrings is apt to cause a sacro iliac lesion while trauma applied from above with the spine in a position of flexion is more apt to affect the lumbo sacral region

When the patient is a woman the history of previous pregnancies and labours should be considered It may also be possible perhaps to trace the onset to exposure to cold with resulting myositis or to an attack of fever which might be followed by a local infection of the lumbar fasciæ

(e) *What improves the pain?* Is the pain improved by resting? This is often the case in the back pain due to foot errors and in chronic occupational strain

(f) *What makes it worse?* In the above cases and in tuberculosis and neoplasm exercises and unguarded movements cause acute pain Any awkward stooping position while at work increases the ache in sacro iliac and lumbo sacral strains Coughing sneezing and straining at stool aggravate the pain in sciatica due to radiculitis or to retro pulsion of an intervertebral disc and in acute sacro iliac conditions

Patients with acute sacro iliac strain cannot lie for any time on the affected side whereas those with lumbo sacral strain lie comfortably on either side or on the back

(g) *Is it worse in the morning?* In organic diseases of the spine the pain is better in the morning but in chronic strain the back is apt to give more trouble then than at night

(h) *Stiffness* Does he complain of stiffness and if so where is the stiffness? When is it most noticeable? Stiffness usually indicates some arthritic change and is therefore most marked in the morning the site depending on the joint or joints affected

Accompanying Complaints in Other Parts of the Body

(a) *Feet* Does the patient complain of his feet or does the back ache increase with standing or walking? Foot strain is a common etiological factor in low back pain

(b) *Other Joints* If he complains of pain in other joints rheumatism or osteo arthritis may be considered

(c) *Genito urinary Symptoms* If he has any frequency of micturition or dysuria a careful urological and X ray examination should be carried out

(d) *Gynæcological History* In women the condition of the reproductive organs should be the subject of inquiry and a thorough gynæcological examination made if any suggestive symptom is discovered. Pain which is increased during menstruation suggests a chronic ligamentous strain as the ligaments of the pelvis relax at that time.

(e) *Neurosis* The mental balance of the patient and in the wage-earning classes particularly their attitude towards work and compensation must be carefully assessed.

(f) *History of other Diseases* Osteomyelitis arthritis gonorrhœa typhoid fever tuberculosis syphilis and any possibility of neoplasm should be excluded.

(g) *Constipation* Sir T. R. Fraser has shown how frequently low back pain may be associated with a loaded colon so that a careful history of the bowel action should be taken.

EXAMINATION OF THE PATIENT

The patient is stripped and examined in both the erect and recumbent positions.

1 *Standing* The general posture weight muscular development and tone are noted. Careful observation is necessary for some minor abnormality of posture which the patient adopts for instance a slight degree of flexion at the hip and knee which relaxes the hamstring muscles may be due to chronic sacro iliac strain on the side concerned.

The spinal curves are examined and any deviation from the normal noted. A slight tilt of the pelvis which has resulted from the shortening of one limb and which has caused a compensatory scoliosis may be the error of posture responsible for the symptoms.

The movements of flexion extension and lateral flexion are carried out and abnormalities such as rigidity muscle spasm or the production of pain noted.

2 *Sitting* *Movements of the spine* both active and passive are investigated in the manner indicated above.

The reflexes are tested the possibility of active focal sepsis in the teeth and tonsils considered the condition of the circulation observed and blood pressure readings recorded.

3 *Lying* *Measurement* of the length and girth of the limbs is carried out.

Joints of the Legs The contour and range of movement of the joints of the legs are observed.

Abdominal palpation is carried out.

Points of tenderness are sought particularly in the coccygeal sacral and sacro iliac regions in the posterior inferior and superior spines the ilio lumbar ligaments the lumbosacral joint and the spines and transverse processes of the lumbar vertebrae. The presence of tender fibrositic nodules may be of importance in arriving at the final diagnosis.

The effect of lateral compression of the iliac crest is observed. Rectal and prostatic examinations are made.

Special tests are of great value in the differential diagnosis and location of low back pain. Forceful compression of the iliac crests often elicits pain in the sprained sacro iliac joint, but usually has no effect on the lumbo sacral sprain. Laguerre's sign, which consists of forcing the leg in flexion, abduction and lateral rotation, causes pain in the affected sacro iliac joint. As a rule, this manœuvre does not cause pain in a painful lumbo sacral area. Goldthwaite's and Gaenslen's signs similarly produce pain in the affected sacro iliac articulation with slight effect upon the lumbo sacral. In the former sign, the thigh is strongly flexed with the knee extended. The tension of the hamstring muscles produces a rotatory force upon the painful sacro iliac joint. In the latter sign, the thigh and the knee on the affected side are flexed so that the extremity is pressed against the abdomen. Then upon hyperextension of the opposite hip, pain is felt in the affected sacro iliac joint. It is often very difficult to fix the spine so as to relieve it of stress when exerting force upon the sacro iliac joints, or to fix the sacro iliac regions in a position of relief while placing stress upon the lumbo sacral junction. This is especially so when the sprain is acute and has associated spastic limitation of motion.

The X-ray Examination. An antero posterior and lateral view of the spine, extending well above and well below the suspected site, should be taken. In many cases, a stereoscopic view of the lumbo-sacral and sacro iliac regions should also be obtained, as many conditions, and especially those of the lumbo sacral articular facets, cannot be properly appreciated except by this particular method.

Laboratory Examination. Examination of the urine, blood, and cerebro spinal fluid, and a Wassermann test, complete the investigation.

THE COMMON CAUSES OF LOW BACK PAIN

1 Low Back Pain associated with Congenital Errors

(a) The Vertebral Body.

The bodies of the vertebrae ossify from two separate centres which may be alongside each other, be superimposed, or even be one behind the other. A variety of anomalous radiological shadows is therefore met with. When the two centres of ossification do not develop properly, or fail to fuse, the X ray appearance is that of a split body, and there is often some separation between the two halves. Care should be taken not to confuse a true failure of fusion between the centres with the apparent splitting of the vertebral body occasionally seen in children and young adolescents. In the latter case, there is an apparent separation between the upper and lower halves of the body, but the cleft is anterior to and extends only as far as the centre of the body. The appearance has no clinical significance, and is thought to be due to delayed union of the notocordal segments. A split body does not give rise to deformity, but if one of the true centres actually fails

to appear, a hemivertebra is produced and leads to a spinal curvature usually a scoliosis. The balance of the erect posture is then altered and compensating secondary lateral curvatures arise.

Sometimes two vertebral bodies may be fused together but this condition is usually symptomless.

The Articular Processes The articular facets of the lumbo-sacral joints show great variations in shape, and in the plane of their surfaces. Normally the articular processes are vertical, and the facets lie in the sagittal plane but on one or both sides the processes may

show the characteristics of the thoracic region where the facets face forwards and backwards respectively. In other cases, one facet may be directed backwards and the other medially.

When the facets are thus asymmetrical abnormal movements may occur. Brailsford found that the articular facets of the fifth lumbar vertebra were directed in various ways: 57 per cent backwards, 12 per cent medially, and 31 per cent mixed the directions on the two sides being different.

(b) The Neural Arch

The principal anomaly occurring in this region is a lack of fusion between the two halves of the arch. The condition occurs either in the fifth lumbar or in the first sacral vertebra, and the defect is situated in the mid line, thus constituting a spina bifida occulta. The only evidence of such an error may be a small lipoma, a tuft of hair, or a dimple in the skin of the lumbo-sacral region. There may be no symptoms although fre-



FIG. 223.—Congenital abnormality of the first lumbar vertebra producing a kyphus in the lumbar region.

It is sometimes associated with other congenital abnormalities, such as limitation of other joint movements, cloudy cornea, etc. Note also the indentation in front of some of the vertebrae. This is a delayed fusion of the primitive notocordal segments. (Mr. Armstrong's case.)

quently there are co existing deformities of the lower limb e.g. pes cavus. Instability in the lumbo sacral region and low back pain are common accompaniments.

In addition to this central defect there may be anomalies in the attachment of the laminae to the body on one or both sides. These may be found along with the commoner central defect. All varieties of congenital error in this situation are more common in males.

Spondylolisthesis the name given to that deformity of the lumbo sacral region produced by the gradual gliding or slipping forward of the lumbar spine on the sacrum first attracted the attention of obstetricians in 1853 when Kilian recognized it as a definite



FIG. 24. Spina Bifida of the first Sacral Vertebra

clinical entity and considered it to be chiefly a disorder of women. It has however been shown since to affect men more often than women. The condition is primarily due to an important variation in the ossification of the fifth lumbar vertebra where instead of one primary centre for each half of the vertebral arch there are two primary centres in each half the two parts being united by a plate of cartilage set obliquely between the superior and inferior articular processes. In such a case the posterior part of the arch of the vertebra consisting of the spine lamina and inferior articular processes is occasionally separated from the rest of the bone union being effected by hyaline cartilage only. A similar condition may be seen in the fourth and occasionally in the third lumbar vertebra so that the

deformity may be between the third and fourth or between the fourth and fifth, or at the lumbo sacral junction

The apposition of the inferior articular processes of the fifth lumbar vertebra with the articular processes of the sacrum checks any forward displacement of this vertebra, but, if there is any solution of continuity between the superior and inferior articular processes of the fifth lumbar vertebra, displacement may occur at the joint owing to the superincumbent body weight acting as a shearing strain overcoming the resistance of the weaker ligamentous structures. This slipping takes place slowly and gradually, probably over a matter of years. In those cases where a snap is felt in the back it is believed by Neugebauer that secondary infraction of the interarticular portions

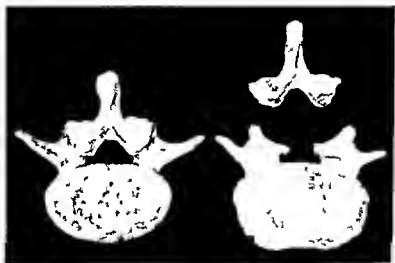


FIG. 27a.—Specimen of the Fifth Lumbar Vertebra showing Congenital Non fusion of the Posterior half

of the arch takes place and gives the patient the sensation of a snap. The posterior part of the arch remains in place. The body, with the anterior part of each of the lateral masses, slips downwards and forwards carrying with it the superincumbent vertebral column.

The average age of patients who suffer from symptoms from this deformity is about 40 years although cases have been reported as old as 80 and as young as 5.

ETIOLOGY

It is probable that the development of spondylolisthesis is due to trauma in the presence of a congenital defect. Such trauma may be sudden and severe, or it may be the mild and long continued jarring of the spinal column in walking. Capener has pointed out the importance of the wedge like influence provided by the upper and posterior borders of the sacrum (Fig. 276). The apex of the wedge is formed

by the articular facet of the sacrum and splits the fifth lumbar vertebra into two portions at the site of the congenital non union. Thus is initiated spondylolisthesis.
THE CLINICAL PICTURE.

The patient complains of low back ache and pain in the lower extremities, but in the majority of the younger individuals such symptoms are entirely absent. The symptoms may be summed up briefly as follows—sometimes without previous injury but generally after a single or repeated trauma a deformity of the spine develops gradually accompanied by pain referred to the lumbar region and radiating down into both lower extremities. The pain is relieved by rest and aggravated by hard work. It is of a dull aching character. Weakness and stiffness of the spinal column are usual although only a few of the patients notice deformity. Occasionally shortening of the torso and decrease in height have occurred. Some of the patients have a slight waddling gait and some a marked hump.

PHYSICAL SIGNS

In the fully developed case the trunk is shortened and transverse furrows are seen encircling the body between the ribs and the iliac crest. There is a diminution of the space between the ribs and the crest of the ilium and between the xyphoid cartilage and the pubis. The sacrum is prominent and there is a still greater prominence of the fifth lumbar spine with a depression above. The shortening of the trunk gives an appearance as though the spine had been telescoped into the pelvis. This makes the iliac crests appear to rise whereas in congenital dislocation of the hip the shortening of the trunk is due to the descent of the pelvis. The latter condition exaggerates the antrochanteric diameter in relation to the hi iliac which is lessened. In spondylolisthesis on the other hand the hi iliac diameter normally the smaller becomes larger and appears different in shape from the normal.

The slipping of the vertebra produces an angulation rather than a curve so differentiating the condition from an aggravated normal lordosis. The antero posterior pelvic diameter is diminished and the anterior superior spines are rotated backwards through a considerable arc. Tchirkin has described a physical sign which he maintains is pathognomonic of acute spondylolisthesis. He says that the lordosis

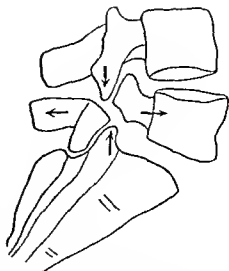


Fig. 6—Diagram showing the wedge like influence of the upper and posterior part of the Sacrum further splitting the unfused segments of the Lumbar Vertebra (Capener)

of spondylolisthesis is associated with a compensatory forward bend of the spine in the region between the flexible lumbar and immobile thoracic vertebræ producing a slight kyphosis of the first lumbar spinous process

The presence of spondylolisthesis may be suggested to obstetricians by asymmetry of Michaelis rhomboid—the rhomboid figure formed by the lines joining the dimple over the tip of the fifth lumbar spine to the posterior superior spines above and the convergence of the buttocks below

A slight degree of scoliosis is frequently present owing to the unequal slipping forward of the vertebræ and the consequent rotation

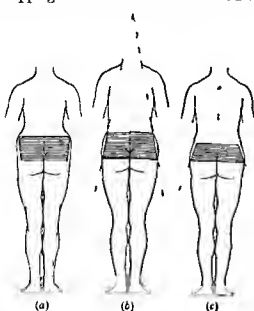


FIG. 277.—Diagram to illustrate the differences in the Bi iliac and Bi trochanteric Measurements in various conditions

- (a) Spondylolisthesis. The forward rotation of the pelvis increases the bi iliac diameter
(b) Normal
(c) Congenital dislocation of both hips increases the bi trochanteric measurement

of the spine is restricted while lateral movements are free. There may be a limitation in hip extension but in most cases the patient can touch his toes in the straight leg bending exercise. On abdominal palpation a prominence of the fifth lumbar vertebra may be present, and may be confirmed by vaginal examination

X ray Appearance The diagnosis is confirmed by radiographic demonstrations of the displacement. In the antero posterior radiographs a characteristic arc or bow is seen which is the shadow of the anterior border of the transverse process continuing on to the anterior border of the body. This appearance is produced by

the X rays penetrating the fifth lumbar vertebra from above instead of from the front. The lateral radiograph furnishes absolute proof of the presence of any anterior slipping of the fifth lumbar body on the sacrum. The outlines of both vertebræ are shown and consequently the line of the posterior and anterior borders of the body can be seen. If a line is drawn connecting the anterior surface of the lumbar vertebra it will be seen to form a curve its centre of convexity depending on the lumbo sacral angle but if the fifth body has slipped forward on the sacrum a definite break will be seen in the regularity of the curve. Normally when a straight edge is placed along the shadow of the anterior border of the first sacral body it will project upwards and

forwards well to the front of the shadow of the fifth lumbar body, but in spondylolisthesis the straight edge will cut into the body of the fifth lumbar vertebra. This is known as Ullman's sign. ✓

One of the most characteristic features which is usually seen best in early cases, is a break in the lamina. This may appear as a gap continuing the clear space of the lumbo sacral joint backwards above the spinous process of the fifth lumbar vertebra.

As evidence of spontaneous arrest bony buttress formation may



FIG. 278 — Antero Posterior Radiograph to show the characteristic bow appearance. Scoliosis can also be observed from unequal slipping forward of the body.



FIG. 279 — Lateral Radiograph to show slipping forward of the body of the Fifth Lumbar Vertebra on the Sacrum.

be seen attached to the anterior surface of the sacrum under the projecting portion of the fifth lumbar vertebra, and the lower articular process of the fourth lumbar vertebra may rest on the sacrum. In extreme cases the inferior surface of the fifth lumbar body is shown in close apposition to the anterior surface of the first sacral body with which it may be ankylosed, or it may glide still lower and reach even the third sacral vertebra.

TREATMENT

Many cases of spondylolisthesis have comparatively few symptoms and accordingly in these cases no treatment is indicated. By the

time the patient presents himself there is no possibility of reducing the displacement, as the soft structures have by this time become firmly fixed and shortened and in any case there is no method of getting sufficient leverage to produce a reduction. Where the symptoms are slight a conservative method of treatment is adopted by fitting the patient with a strong lumbo sacral corset reducing the weight where necessary and instituting postural exercises and physiotherapy. The results are often excellent though for men doing heavy labour it is usually found necessary to change to a lighter occupation.

Where the symptoms are extreme some operative method should be considered and the method is usually one whereby the affected area is fused by grafting of bone.

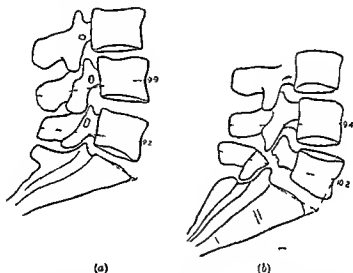


FIG. 980.—Diagram illustrating Diagnostic Signs on the Radiograph

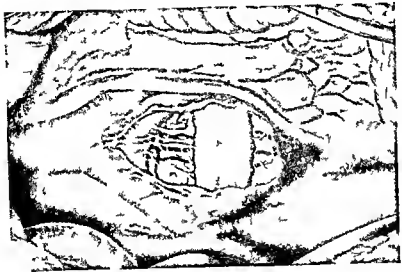
- (a) The normal appearance
 (b) 1. In spondylo listhesis the abnormal vertebra measures more than the one above it from the tip of the spinous process to the front of the body
 2. Uhlmann's sign. The body of the fifth lumbar vertebra projects in front of a perpendicular line drawn up from the front of the sacrum

1 Posterior Arthrodesis An arthrodesis of this part of the spine may be carried out after the method of Albee or Hibbs fixing the spinous processes above and below as is done in a tuberculous spine. This method helps to fix the slighter cases but if there is any tendency for the deformity to increase a shearing strain is put upon the graft which may bend or break and fail to limit the increase in deformity.

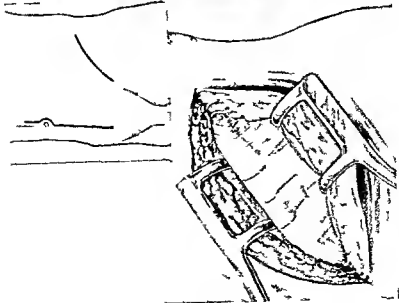
2 Burns's Method Burns has described a method of pegging the bodies of the vertebrae from the front. The deformity is approached by an anterior supra pubic abdominal incision and a bone peg is



(c)



(b)



(a)

FIG 281—Operation for Spondylolisthesis
(a) Preparation of bone grafts from iliac crest. Inset, double incision (b) Exposure of fifth lumbar vertebral body. Inset, bone grafts and vertebral body fixed by wire mesh screw (c) Bone graft placed in situ above and upper edge of first sacral

driven down and back through the body of the fifth lumbar vertebra into the sacral bodies. This helps to fix the slipping vertebra but here again a considerable shearing strain is produced on the peg which may be easily broken.

3 *The Author's Method* The author's method may be used in some cases and has the advantage of fusing the bodies of the vertebra together and is probably more effective in preventing further displacement. The approach is made through a supra pubic abdominal incision and the gap between the sacrum and the slipping vertebra is dissected free of the overlying soft tissue.

By means of an osteotome a rectangular gap is produced between the sacrum and the displaced vertebra extending backwards for about $\frac{3}{4}$ inch. This gap is produced by removal of $\frac{1}{4}$ to 1 inch of the contiguous margins of the lumbar vertebra and sacrum and the intervening intervertebral disc. Autogenous bone grafts are now taken from the crest of the ilium to wedge into the gap. These are fairly accurately fitted and punched home into the gap. The method can be followed in Fig. 281.



FIG. 282—Spondylolisthesis.

A very typical case showing the transverse skin creases.

Dandy approaches the condition from another angle. He believes that the signs and symptoms of spondylolisthesis are precisely the same as those of displaced intervertebral discs without spondylolisthesis and that indeed these are produced by the disc displacement rather than that of the lumbar body. In at least 90 per cent of cases there are two or three discs which cause the backache and sciatica. A cure results when the discs are completely removed. The end result of removal of the discs is fusion of the opposing vertebrae and therefore stabilization of the spine. This obviates

the necessity of fusion by means of bone grafts to the spine. Dandy's statistics are hopeful. In some cases therefore the neurosurgeon approaches the area by an interlaminar exposure, removes the disc and may even promote fusion by the insertion of small bone chips into the disc space.

(c) The Spinous Processes

If the laminae fail to fuse the epiphyses for the spinous process may remain separate and give rise to a distinct bone which can occasionally be seen in radiographs of the lumbosacral region. In other

cases, the spinous process may unite to the neural arch on one side only

Kissing Spines. Normally between the spinous processes a distinct interval exists. In certain cases this interval is diminished, and the spines may be brought into contact, or even overlap. In the X rays a condensation of the bone may be detected on the margin of each spine where it is in contact with the other. A supernumerary joint is thus formed and instead of two lateral joints on which the vertebrae swing forward and backward as on a hinge, the patient has three, arranged as a triangle. Any one or all of these may be sprained, giving rise to pain. Some specimens of spinous processes show cartilage on the margin of the spine, and that the spines are actually in contact can be demonstrated at operation. A joint in this situation is exposed to constant strain.

This is a very real although comparatively rare, cause of backache. The physical signs are not clear cut. In spite of the pain, mobility except in extension is not usually restricted. A list of the trunk may be present. The diagnosis is made from the radiographs but may easily be overlooked unless the possibility be kept in mind.

TREATMENT

The reduction of movement in the lumbar spine by means of a lumbo-sacral brace may produce some alleviation of symptoms. The rational treatment is operative. An ankylosing operation may be performed on the two vertebrae the spines of which impinge but better and far simpler is the resection of one or both spines close to their origin from the neural arches.

(d) Transverse Processes of the Fifth Lumbar Vertebra

Most of the anomalies of transverse processes concern the fifth lumbar vertebra of which they comprise by far the most variable components. Variation in the size and shape of the transverse processes of the remaining vertebrae, such as may be seen in the third lumbar vertebra especially in women, is of little clinical significance.

Sacralization of the Transverse Processes of the Fifth Lumbar Vertebra. Sacralization is a developmental anomaly in which one or both transverse processes of the vertebra become abnormally large and strong. They may become so large that they form a more or less intimate connection with the base of the sacrum or ilium, and by this union a foramen forms between the lower margin of the transverse process and the upper free edge of the sacrum instead of the normal broad and irregular cleft. In such cases the transverse process often has the appearance of a butterfly's wing.

PATHOLOGY

The so called transitional vertebrae are vertebrae which by transition from one segment of the vertebral column to another have acquired the characteristics of both segments. Instances of this are seen in the so called cervical rib which is really a dorsalization of the seventh

cervical vertebra. Nichol compares the ventral portions of the lateral parts of the sacrum with rudimentary ribs.

Ossification of the sacral vertebrae proceeds from three centres of ossification, one in the body and one in each of the two lateral processes, but in the first, second and third sacral vertebrae there appears, ventral to the centre of ossification in the lateral process, an extra centre of ossification analogous to the costal element which is the important factor in the production of a cervical rib.

Le Double has described five types or degrees, of sacralization, but the first and second of these degrees are probably enlarged transverse processes rather than sacralized processes. In his third degree the fifth lumbar vertebra is still normal, but one or other of its transverse processes is stronger than usual, and towards the free end has a smooth or rough protuberance which articulates with a correspond

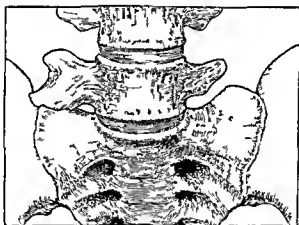


FIG. 283.—Sacralization of the Transverse Process of the Fifth Lumbar Vertebra (Fourth degree of Le Double.)

ing surface on the lateral aspect of the sacrum, so that on this side an extra sacral foramen can be demonstrated. In his fourth degree, the body and strong hypertrophic transverse process begin to form one coherent mass and the transverse process now articulates through a facet or through a rough surface as much with the sacrum as with the ilium. Here also there is an extra sacral foramen in the form of a horizontal oval. In the fifth degree, the disposition is the same as in the fourth but is bilateral.

THE CLINICAL PICTURE

The patient, either a male or a female, usually begins to complain of symptoms about the age of 18 to 20. There is pain on the affected side low down in the back. Often there is a history of some trauma, a strain or a twist of the back, from which the symptoms date. Thereafter the pain becomes almost continuous and is accompanied by a

pain may shoot down to the back of the leg. The patient is unable to sit comfortably on the buttock of the affected side. The pain is worse after exercise or when tired, but is improved by the wearing of tight corsets and by lying in bed on the back or in the ventral position.

On examination it will be seen that the patient walks somewhat stiffly but without a definite limp. He is able to bend forward well but the back is kept stiff. Hopping on the leg of the affected side increases the pain. He rises from the stooping position slowly and with pain.

On inspection it will be seen that there is a certain amount of flattening of the lumbar curve. The spinous processes of the lumbar vertebrae appear to be slightly displaced to the affected side so that there is a lumbar scoliosis with convexity to the affected side. This remains even in the sitting posture. The sacrospinous ligament is tense on the affected side. The lower limbs are normal in movement and musculature as are the sensation and reflexes. There is marked tenderness over the sacroiliac joint on the affected side, and to a less extent down the sciatic nerve. There is no pain on compression or distraction of the crests.

On X ray examination the degree of sacralization of the transverse process may be seen. The body of the fifth lumbar vertebra is slightly displaced laterally towards the abnormal process. There is a scoliosis with the convexity towards the affected side. The enlargement of the transverse process will be noted and it is important to determine by means of stereoscopic X rays whether or not the free end of the process is impinging on the ilium. Between the body of the vertebra, and the sacrum and the transverse process, a well marked intervertebral foramen will be noticed.

Although this anatomical anomaly has been present since childhood it usually does not produce symptoms before the age of 20. This discrepancy is connected with the ossification of the vertebral column, and it is only when the column has acquired its final stiffness that the asymmetrical fixation of the fifth lumbar vertebra to the pelvis may produce symptoms. Up till then the natural resilience of the relatively soft bone does not cause sufficient pressure to give rise to symptoms, nor does it fix the spine so firmly.

For the explanation of the flattening of the spine and the scoliosis one must turn for a moment to the development of the spinal curves. The normal curves of the adult spine are only partially present at birth. They develop later under the influence of the upright carriage. Early in the life of the embryo the so called primary curves in the thoracic and sacral regions with the concavity forwards can be demonstrated, while the so called secondary or compensatory curves in the cervical and lumbar regions develop during the first few years of life—the cervical curve when the child can hold the head erect, and the lumbar curve when the child can walk, i.e. between 2 and 3 years of



FIG. 284—Sacralization of the Fifth Lumbar Transverse Process

The degree of the enlargement of the process and the lateral enlargement of the vertebra can be observed.



FIG. 285—After removal of the part of the Abnormal Process impinging on the Hum

This completely relieved the patient of pain

age The transverse process of the fifth lumbar vertebra in the normal fully grown skeleton lies more than one centimetre anterior to the posterior superior iliac spine so that during the development of the secondary lumbar curve the fifth lumbar vertebra slips forward a little in relation to the ilium and sacrum With these portions of the skeleton it does not make bony union, but is united only by means of its articulation and ligaments When a sacralization is present the transverse process has grown towards the lateral mass of the sacrum or the ilium in its posterior part as well and has become fixed to either or both This fixation of the lumbar vertebra to the pelvis is of course abnormal In the normal development of the secondary lumbar curve the fifth lumbar vertebra remains with its one transverse process fixed posteriorly by its union with the sacrum or ilium In this way originates a scoliosis with its convexity towards the sacralized side This abnormal fixation likewise explains how the fifth lumbar vertebra is drawn over towards the sacralized side since being fixed at one side and free at the other the natural result is that the growth of both sacrum and fifth lumbar vertebra will be somewhat greater on the free side

The form of the intervertebral cartilages and the fifth lumbar vertebra depends on the secondary lumbar curve These become wedge shaped with the base situated anteriorly while the remaining lumbar vertebrae have the same height anteriorly as posteriorly so that according to the degree of wedge shape taken by the fifth lumbar vertebra during the growth period and to the amount of forward displacement of the vertebra there is a greater or less degree of lumbar lordosis When the fifth lumbar vertebra is fixed posteriorly by a broad unilateral or bilateral sacralization it cannot participate in the formation of the secondary lumbar curve by moving forward the curve therefore does not develop and instead of the normal lordosis a flat back results This appears to be the explanation of the flat back and the scoliosis in these cases The flat back can be accentuated still further by secondary muscular spasm

Various theories have been put forward for the local pain It has been suggested that it might be due to compression of muscle or fibrous tissue between the process and the sacrum or ilium irritation of a bursa or arthritis of the new joint while many have suggested that it was due to compression or stretching of nerve fibres where they leave the column The fourth lumbar nerve is said to be occasionally stretched over the large transverse process The posterior branch of the fifth lumbar nerve comes out in front of the transverse process of the fifth lumbar vertebra which even in its worst form appears to leave sufficient room for the branches of this nerve Most of the X rays of sacralization show an ample interval between the body and the transverse process of the fifth lumbar vertebra and the lateral part of the sacrum while in none of the cases reported is there definite evidence of clinical symptoms arising from a nerve compression

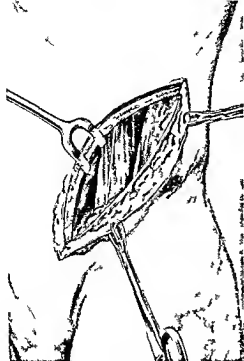
The probable cause of the pain which is situated in the region of the sacro iliac joint is a distraction of this joint produced by the leverage of the abnormal process in lateral movement of the spine. The process impinges on the ilium and strains the ligaments of the joint.

TREATMENT

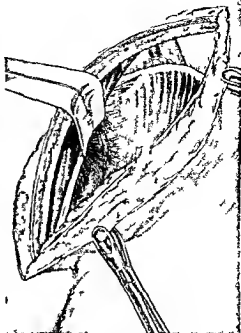
The removal of the offending process would appear to be the rational form of treatment though an arthrodesis of the sacro iliac joint has also been suggested.

Posterior Route This is probably the route of choice. Bonniot has described the anatomy and though the process is situated deeply a comparatively easy removal can be achieved if a large triangular segment of the ilium is freed by an osteotomy and turned downwards. The area is approached through a curved incision like that used by Smith Petersen for his sacro iliac operation. A good view of the process is got and it is freed by curved elevators which are left in to protect its anterior aspect while severing it. The triangular segment of ilium is replaced and heals quickly.

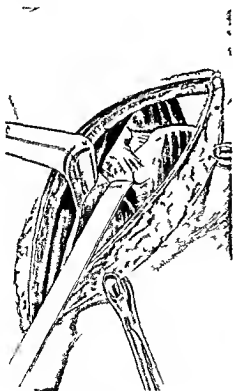
Anterior Route With the patient on his back and with the hips flexed to relax the psoas a long incision is made as though exposing the lower end of the ureter. It extends from the costal margin down into the right iliac fossa in the line of the fibres of the external oblique. This muscle is split in its length right up into its muscle belly. The internal oblique and the transversalis are then cut across in the line of the skin incision and the peritoneum exposed. The peritoneum is swept medially by means of gauze dissection and packed there with a gauze swab and the whole operation carried out extra peritoneally. The ureter is carried medially with the peritoneum. The iliacus muscle with the lateral cutaneous nerve of the thigh running across it and the psoas muscle are thus exposed (Fig. 286 a) and a finger is inserted to localize the posterior part of the iliac crest. This is located and the examining finger pushed along it until the abnormal process is felt and it is felt quite easily. The femoral nerve is seen at the lateral border of the psoas and along with the genito-femoral nerve and the obturator in the muscle at this part is retracted medially and anteriorly (Fig. 286 b). The iliacus muscle is now incised at its medial part where it is attached to the posterior part of the iliac crest and the fibres of the anterior sacro iliac ligament are turned downwards (Fig. 286 c). Lying behind the muscle and in front of the abnormal process there is a mass of adipose tissue and in it at the base of the process are three branches of the fourth lumbar nerve: one to the sacro spinals, one to the obturator and one to the femoral. A descending branch of the fourth artery and vein may be found passing over the transverse process at its base. These may lie in the substance of the psoas but in any case give rise to no operative difficulty. The parent trunks to the fourth lumbar vessels lie a variable distance above the upper border of the fifth transverse process. Occasionally they are in actual contact with the process and might



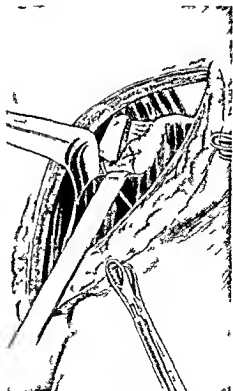
(a)



(b)



(c)



(d)

FIG 286—Operation for Resection of Fifth Lumbar Transverse Process by Anterior Route
 (a) Psoas exposed. (b) Psoas retracted. (c) Iliacus reflected (d) Portion of transverse process removed.

require ligation. With a blunt periosteal elevator the fatty tissue is elevated medially to expose the abnormal process. A very good view of the process is now obtained and by means of an osteotome the part articulating with the ilium is cut off (Fig. 286 d). There is usually no bleeding. It is easy to remove the greater part of the process. The wound is stitched up in layers and a small rubber drain inserted for 24 hours.

2 Low Back Pain following Trauma

(a) Sacro-iliac Strain

ETIOLOGY

There is a small but measurable range of movement at the sacro-iliac joints. This may be proved in a spare subject by measuring the distance between the posterior superior spines of the iliac bones in the erect position and repeating the measurement in the sitting position. It will be found that the figures obtained differ by as much as three quarters of an inch.

The opposing sacral and iliac surfaces of the joint are irregular, but so arranged that the opposing irregularities fit together accurately. The opposing surfaces are smoother in the female joint and thus the range of movement is greater in the female, attaining its maximum range in childbirth but the structure of the joint must of necessity be weaker. The condition to which the term "sacro-iliac strain" is

applied occurs when, as a result of mechanical force or injury, the joint becomes locked at one or other of the extremes of range of movement. It may frequently be demonstrated in spare subjects that the ilium is displaced forward in relation to the sacrum by palpation of the posterior superior spines when it will be noted that the spine on the affected side is less prominent than the spine of the normal side. The locking may occur as a result of the stress incurred while lifting a heavy weight or of the strain of increasing obesity, or during pregnancy, when the shearing strain due to the increase of lumbar lordosis in addition to the laxity of the sacro-iliac ligaments makes displacement of the joint a matter of common occurrence.

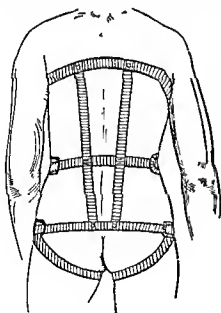


FIG. 287—Low Back Pain. Type of appliance useful in cases of strained back especially of the lumbo-sacral joint.

SYMPTOMS AND SIGNS

The symptoms accompanying sacro iliac strain vary considerably, but certain features are constantly present

Pain Pain is experienced over the posterior aspect of the joint and may be elicited by digital pressure in that area. It is increased by movements which put added strain on the joint. It is constantly more severe at night because the recumbent position obliterates the normal lumbar lordosis and throws more strain on the joint. Exacerbations also occur at the menstrual periods as the increased congestion at that time causes softening of the joint ligaments and increased joint mobility. Standing or sitting for long periods also leads to an aggravation of the pain. Lateral distraction or compression of the iliac crests may or may not produce pain in the joint.

Attitude In standing the body is usually inclined away from the side of the affected joint. At rest the knee and hip will be noted to be slightly flexed on the affected side—an attitude which decreases the strain on the joint. In rising, the spine is usually held rigid and the hands frequently used to obtain additional support. In stooping, flexion of the trunk is avoided. When the condition is acute, long steps in walking are impossible because of the co existing spasm of the hamstrings.

Limitation of movement Movements of the body on the thighs, or of the thighs on the body, are limited. Forward bending of the trunk with the knees held straight is restricted if the lesion is of any magnitude. To determine whether the limitation is the result of spinal disease or of sacro iliac disease, the tension of the hamstring muscles should be released by allowing the patient to sit. Similar movements are now attempted, when the spine is involved the limitation will be found to persist, but in lesions of the sacro iliac joint flexion can now be carried out easily and without pain.

When attempts are made to flex the hip with the knee fully extended, marked limitation is present in sacro iliac lesions and attempts to increase the range of movement cause pain referred directly to the sacro iliac joint involved. This phenomenon is known as Goldthwaite's sign.

Albee states that the following symptom complex is almost pathognomonic of sacro iliac disturbance

(a) Pain in the region of the joint on turning over from the recumbent position

(b) Discomfort while lying on the back

(c) Pain while sitting on a hard chair, relieved by sitting on the opposite buttock

(d) Pain in the affected joint on forward bending

(e) Pain on deep pressure over the affected joint

(f) Listing of the whole spine to the opposite side

(g) Positive Goldthwaite's sign

Radiographic Appearances There are no characteristic radiological changes in acute sacro iliac strain. In cases of long standing however, the joint undergoes arthritic change, the radiological appearances of which are

- (a) Increased density along the margins of the joint
- (b) Irregularity of the joint line
- (c) Proliferative changes at the inferior margin of the joint
- (d) Bad alignment of the pubis

DIFFERENTIAL DIAGNOSIS

Sacro iliac strain must be differentiated from acute fibrositis (lumbago) and from lumbo sacral strain

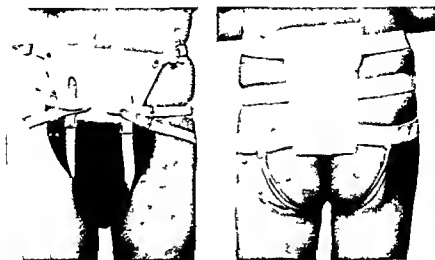


FIG 288 —A supporting Sacro iliac Belt, useful in cases of strain of this joint

TREATMENT

The treatment of both the acute and chronic varieties is essentially by manipulation designed to correct the displacement and to restore mobility in the joint, together with physiotherapeutic measures and spinal exercises to increase muscle tone and correct faulty posture. No manipulative treatment is undertaken until the possibility of tuberculosis, secondary malignant deposits or other gross abnormality has been eliminated in the radiographs.

A single manipulation will usually produce a dramatic result in the acute case and no further treatment may be indicated, but in the chronic form there are usually other etiological factors such as a postural defect, short limb or excessive weight, which must be overcome if anything more than a transient improvement is to be obtained.

The manipulation is carried out under general anaesthesia in acute cases, but in the more chronic forms, where muscle spasm is absent,

anaesthesia may be unnecessary. The patient is turned on the sound side one hand is placed on the shoulder while the other hand grasps the limb of the affected side behind the knee. Pressure is exerted in opposite directions until the vertebrae are locked in the position of full rotation. When full rotation has been obtained the extra pressure exerted by the hand grasping the knee is transmitted through the sacro iliac joint which moves from the locked position with an audible click.

Operative Treatment

In intractable cases which resist conservative treatment and in which the diagnosis has been established beyond doubt complete relief of symptoms may be obtained by arthrodesis of the joint.

The Smith-Petersen Operation has been found by the author to be most satisfactory.

The incision runs along the posterior two thirds of the iliac crest curves round the posterior iliac spine and passes downwards for three inches parallel to the fibres of the gluteus maximus. This semilunar flap is reflected sub periosteally to expose the lateral surface of the ilium. A rectangular window is now cut out of the whole thickness of the ilium over the sacro iliac joint and the joint thus opened. The exposed sacral articular cartilage and the underlying cortex are now removed until cancellous bone is evident at the bottom of the cavity. The rectangular block removed from the ilium is then denuded of cartilage on its sacro iliac surface and replaced and counter sunk so that its cancellous surface makes contact with the cancellous bone of the sacrum. To secure the closest contact and to promote osteogenesis the edges of the defect in the ilium may be broken in over the block. At the completion of the operation the patient is immobilized in a previously prepared posterior plaster shell for a period of two to three months by which time arthrodesis is complete. In many cases it is necessary to arthrodesise both joints.

(b) Lumbo-Sacral Strain

ETIOLOGY

In the embryo of 9 weeks the sacrum is nearly straight and forms a direct continuation of the lumbar region. From this time onwards the sacrum alters its direction and the lumbo sacral angle begins to form. In the adult the average angle is 120 degrees but variations are common. In addition to the great variations in the angle this region is unstable for the following reasons:

- (1) It is the junction of a mobile and a fixed part of the spinal column.
- (2) It is developmentally designed for the four footed position and hence is at a disadvantage in the upright position.
- (3) It is the site of a rotatory action which is often asymmetrical.
- (4) It is the site of great shearing strain.

Structural abnormalities in the lumbo sacral region render this part of the spine more vulnerable to mechanical stress and strain than is normal. This does not imply that all individuals with anomalies in this area have symptoms in consequence but it does mean that if an individual with symptoms referable to the lower part of the back is found to have some anatomical variation in the lumbo sacral region this anomaly may well be held responsible for the symptoms until or unless another cause can be demonstrated.

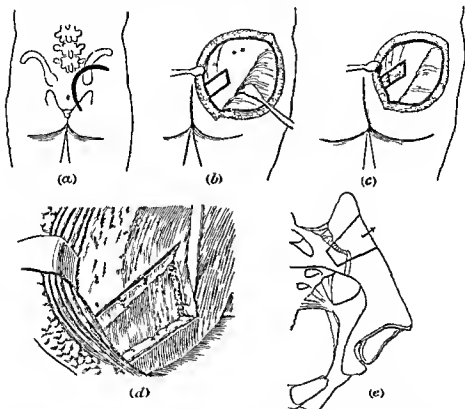


FIG. 289—The Smith-Petersen operation for Arthrodesis of the sacro-lumbar joint.
 (a) The incision. (b) The bone cut outlined. (c) Removal of bone segment. (d) Bone inserted and edge broken over it. (e) The bony union on section. (After Smith & Petersen.)

Lumbo sacral strain occurs in both acute and chronic forms. The acute form may be caused by a sudden blow forcing the joint into positions beyond the normal range of movement by an effort to prevent a heavy article falling or by a sudden body movement while attempting to regain lost balance. The spinal muscles are caught off guard and thus the ligaments sustain the full force of the injury.

The chronic form is usually insidious in onset but may follow an acute strain which has been unrecognized or untreated. It occurs in the long weak type of back with poor musculature and an increase of the normal lumbar lordosis or in a type of patient usually a woman

whose increase of weight in recent years takes the form of a pendulous abdomen. The maintenance of body balance necessitates an exaggeration of lumbar lordosis with consequent increase of the shearing strain at the lumbo sacral angle.

Symptomology. In acute cases with a history of recent trauma the pain and tenderness are situated at the lumbo sacral junction and the movements of the spine are restricted in all directions. A lumbo sacral case will bend forward freely however whether sitting or standing, because he holds the lumbo sacral region rigid and flexes chiefly at the hip joints.

In chronic cases the symptoms vary, some patients merely complaining of a "weak back" which tires easily, while others suffer very acute pain and real disability. Often there is a history of intervening periods of comfort lasting several years, between attacks of pain, but gradually the attacks become more and more frequent or the pain may become constant as age advances.

DIFFERENTIAL DIAGNOSIS

Lumbo sacral strain is distinguished from a sacro iliac lesion by a consideration of the history and the examination of the case. Smith Petersen has summarized the differential diagnosis in convenient tabular form (see next page)

TREATMENT

In the acute stage rest in bed for a period of 2 to 6 weeks is essential. The patient should lie in a bed fitted with fracture boards, and pillows are placed beneath the knees and lumbar spine. When the acute symptoms have subsided, massage, radiant heat and diathermy are of assistance and as improvement takes place graduated spinal and postural exercises are instituted. Chronic lumbo sacral strain presents a more complex problem and dramatic results are not to be expected. It is necessary to seek the underlying cause before local treatment is commenced. Such factors as a postural defect due to deformity of a lower limb, increase of weight causing an exaggeration of the lumbar curve, active toxic foci and constipation must receive attention. Thereafter exercises designed to flatten the lumbar curve, increase muscle tone and improve posture form the essential local treatment. The fitting of a back brace is rarely necessary or desirable, but those patients with pendulous abdomens frequently benefit from the support of a lumbo sacral belt or strong corset.

Manipulation as an isolated measure can only produce transient improvement in chronic lumbo sacral strain but in long standing cases, especially where there is evidence of initial trauma, is of extreme value in mobilizing joints and breaking down adhesions prior to back and postural exercises (see Chapter XVIII).

In severe cases of long standing which have failed to react to conservative treatment, the joint may be arthrodesed in a similar manner to that used for tuberculous disease of the spine (see p 296).

| | <i>Lumbo sacral</i> | <i>Sacro iliac</i> |
|--|---|--|
| History—trauma | Leverage from above with spine in flexion | Leverage—unilateral via lower limb |
| Pain— 1 Referred to | <i>Fifth lumbar</i> <i>First sacral</i> } areas | <i>Fourth and fifth lumbar</i> <i>areas</i> <i>First and second sacral</i> <i>areas</i> |
| 2 Distribution | Lateral side leg Dorsum foot Sole of foot | Especially posterior aspect of thigh and adductor regions |
| Points of tenderness | The lbo lumbar ligaments spinous processes of fourth and fifth lumbar and first sacral vertebrae | Inferior sacro iliac liga- ments Greater sciatic notch |
| Movements of spine (a) Standing | All lumbo sacral motion is restricted | All free except unilateral side bending forward bending in extremes. |
| (b) Sitting | All restricted as in standing position | Forward bending free with hamstrings relaxed. |
| (c) Lying | All restricted. | Free |
| Special tests (a) Straight leg rais- ing | Limited in extremes on both sides equally | Unilateral limitation at small range |
| (b) Compression of pelvis | Nil | Occasional pain in sacro ilac joint |

(c) Injuries of Intervertebral Joints, Ligaments and Muscles

These injuries are produced by such external violence as over stretching of the spinal column and are thus common in the mobile areas of the cervical and lumbar regions

The pain is sudden and although increased by certain movements it is constantly present during the acute stage and is only partly relieved by rest

In addition to severe pain muscular and ligamentous sprains and injuries of the intervertebral joints are frequently associated with limping and with muscular spasm so that the patient holds his spine rigid and walks with a very slow and painful gait. It is often difficult to determine the exact site of the lesion but when the muscle alone is affected the symptoms are intensified when the muscle contracts and when it is put on the stretch. The underlying pathology is simply the rupture of some fibres with consequent exudation and swelling

Healing takes place through the medium of fibrous tissue but it is the object of treatment to avoid the excessive production of fibrous tissue with resulting adhesion formation or fascial contracture.

In ligamentous injuries the pain is deep seated and can be elicited both by movement of the spine and by pressure with the finger. In contrast to muscle injuries active and passive movements in the same direction both produce pain.

Muscle or ligament strains if of long standing are frequently complicated by a referred sciatica and may be associated with mild infective attacks of the nature of acute fibrositis during which the pain becomes more diffuse and tenderness can be elicited over a wider area.

The most common minor injury of an intervertebral joint results from an unexpected movement or sudden strain which causes the joint to lock at the extreme limit of its range of movement. This lesion which occurs most frequently in the cervical region but is also encountered in the lumbar spine causes extreme pain and associated muscle spasm. It may be diagnosed from sprains of muscle and ligament from the history of the type of injury the localised tenderness and muscle spasm and the fixation of the area of the spine affected so that rotatory movement is almost entirely lost.

TREATMENT

In all severe acute traumatic cases the patient is treated by rest in a bed fitted with fracture boards. The back is supported by firm bandaging adhesive strapping a lumbar belt or even a plaster jacket may be necessary. Physiotherapy is contra indicated in the early acute stage as it merely increases local hyperæmia and exudation but when the acute phase has passed radiant heat followed by graduated active exercise is of service. In many cases instant relief can be obtained by infiltrating the carefully located area with 20-50 c.c.s of $\frac{1}{2}$ per cent novocaine. This procedure may be repeated every second or third day and is often of considerable value in accelerating recovery.

In early cases of sprain of muscle or ligament passive stretching or manipulation merely increases exudation and scar tissue formation and is therefore contra indicated. In chronic cases manipulation is of value in breaking down the adhesions which have resulted from excessive fibrous tissue formation.

When the injury can be localized to an intervertebral joint assumed to be locked instant relief is obtained from manipulating the area concerned through its full range of rotation in both directions under nitrous oxide and oxygen anæsthesia.

In many cases particularly those who apply for treatment only at a late stage the symptoms will persist or even become worse. It should be borne in mind that in this type of case the patient consciously or unconsciously exaggerates his symptoms. Indeed injury to the back more than any other lesion is liable to be followed by evidences of a serious and demoralizing neurosis. The spinal symptoms

which occasionally follow railway accidents—the so-called “railway spine” or traumatic neurosis—is especially serious from this point of view. When it is suspected that the patient is exaggerating his disability, or that a frank neurosis has developed, the services of a neurological expert should be enlisted, as the treatment of the mental condition is of more importance than that of the back.

3 Low Back Pain associated with Pathological Changes

(a) *Spondylosis Deformans*—the so called ‘chronic arthritis of the spine (see p. 658)



FIG. 290—Poker Back appearance on Spinal Flexion

(b) **Other Pathological Errors of the Spine.** Specific infections of the spine, e.g. tuberculosis, syphilis, and osteomyelitis are considered in other chapters. Cases of spinal metastases, from carcinoma of the breast, are quite common. Often at the original operation the breast tumour was found to be small and apparently benign, and yet an X-ray film shows evidence of secondary deposits in the vertebrae. Other neoplasms are rare but should be considered.

(c) **Fibrositis (Lumbago)** Fibrositis, which occurs in both acute and chronic forms, is one of the rheumatic diseases, and may be defined as a non-suppurative inflammatory reaction of the fibrous supporting tissues of the body. Names such as myositis, myofascitis, panniculitis, capsulitis, neuritis merely serve to indicate the tissue affected.

The exact etiology of fibrositis is unknown, but one or more of the following factors are known to be of importance:

- (1) Focal sepsis
- (2) Diet
- (3) Defects of Metabolism
- (4) Occupation and Environment
- (5) Climate
- (6) Psychological factors

The diagnosis is based on pain associated with acutely tender areas in the erector spinæ or its attachments or in the region of the muscular attachments to the crest of the ilium

As it is most common to find fibrositic nodules in a large proportion of individuals living in this climate the mere palpation of a fibrositic nodule, even if it is tender, does not of necessity mean that the patient's symptomatology is due to fibrositis. All the other possible or thopædic causes of low back pain must be eliminated before this diagnosis is made. There is often an associated referred sciatica or sciatic neuritis, a further manifestation of the presence of rheumatic disease.

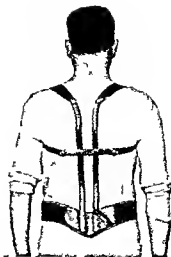


FIG 291.—Spinal Support used in cases of osteoarthritis and injuries to the back

TREATMENT

Treatment is undertaken under three headings in both the acute and chronic forms

(1) **Elimination of one or more etiological factors** This is most important

(a) *Focal sepsis* Teeth, tonsils, antrum constipation

(b) *Diet* It is said that certain cases of chronic fibrositis improve with a reduction of protein or purine intake

(c) *Metabolism* Overweight patients should have a restricted diet and certain female patients may benefit from small doses of thyroid extract

(d) *Occupation and Environment* It is seldom possible to assist here

(e) *Climate* It is of interest to note from the recent publication of the Empire Rheumatism Council that rheumatic manifestations are just as common in hot dry climates

(f) *Psychological Factors* It has already been stated that fibrositis in a mild degree is a common finding in many individuals in this climate. Certain individuals with a low threshold for pain, and who are "misfits," produce symptoms whenever they come up against any difficult situation. This type of fibrositis is referred to by Continental physicians as "fibrositis neurotica" and, needless to say, is most difficult to treat.

(2) **Treatment of the general condition** Apart from general treatment which may be directed by the etiological factors mentioned, such treatment is confined to the very acute case with marked constitutional disturbance when it will be necessary for the patient to obtain complete rest in bed. The bowels are opened with 2 grains of Calomel, followed by half an ounce of magnesium sulphate on the following morning. A light diet is prescribed together with large quantities of

bland fluid Pain may usually be controlled by 10/15 grains of Aspirin three times daily

(3) Local treatment of the very acute type consists of rest and some form of local heat from an infra red lamp, hot bottles, or even from a hot iron

The local treatment of sub acute and chronic cases consists of 15 minutes application of heat from a radiant heat or infra red lamp, followed by deep kneading to break up the fibrous nodules and disperse the products of the inflammatory reaction The patient must expect some considerable discomfort from this deep massage if it is to prove of any benefit Gentle massage is quite useless This period of deep kneading should be followed by a period of active spinal exercises to maintain mobility and prevent contraction of fibrous tissue

When the condition is limited to a very few localized tender areas, infiltration with $\frac{1}{2}$ per cent Novocaine is of value The solution is injected accurately into the tender area, under pressure, with the intention of breaking up the nodule 20-50 c c's may be used, and the treatment is followed by vigorous massage and active back exercises In addition to this treatment chronic cases, in which the capsules and peri articular areas of the intervertebral and sacro iliac joints have become infiltrated with fibrous tissue and the hamstring muscles shortened benefit from manipulation of the lumbar spine and sacro iliac joints under general anaesthesia together with stretching of the hamstring muscles

(d) Typhoid Spine

The spine is occasionally involved during convalescence from typhoid fever The original fever may have been comparatively slight, and often there appears to be no reason why the spine should be infected In some of the recorded cases there was a previous history of hard exercise, which may to some extent have traumatized the spine

The condition (an osteomyelitis) may begin gradually, or acutely, it usually affects males of about 20 years of age. The temperature is raised, and there is a definite leucocytosis

The most prominent local feature is pain experienced usually in the lumbar region Tenderness can be elicited over the affected vertebrae, and in some cases swelling is present as well

Sensory disturbances are usually present, and these vary widely Often there is tenderness along the sciatic nerve, hyperaesthesia of the lumbosacral region, and sometimes anaesthesia of certain parts of the hip and leg The reflexes are usually increased, the abdominal muscles are often rigid and board like, but there is rarely any muscular atrophy

In untreated cases spinal deformities are apt to arise Slade, for example, has recorded a case in which a gibbus developed, involving the segment from the twelfth thoracic to the third lumbar vertebra

X ray examination reveals broadening of the intervertebral discs,

and a considerable deposit of bone on the lateral aspects of the affected vertebrae. In the thoracic region even the costo vertebral articulations may be obscured by the dense mass of new bone.

TREATMENT

A typhoid spine differs markedly from a tuberculous one in that practically all cases make a complete recovery provided they are adequately immobilized.

4 Low Back Pain associated with Static or Postural Errors

Postural errors assumed either from habit in the course of some occupation or from the presence of such abnormalities as weak feet or a protuberant abdomen form a large proportion of the cases of low backache seen by the orthopaedic surgeon. Unfortunately too they are by far the most difficult conditions he is called upon to treat.

Hunter lays great stress on the two distinct functions of muscle viz that of postural tone and that of movement. The former controlled according to Hunter by the autonomic nervous system maintains correct posture without effort or fatigue. When it fails either as a result of some general disease or of neurasthenia posture must be preserved by the exercise of the second or voluntary function. The muscles require to contract actively to do this and fatigue and pain speedily result. If this conception is correct it explains practically all the cases of backache which occur in nervous people.

Certain types of individual are peculiarly liable to such postural strains. The slender type whose posture is bad and who habitually hyperextend the lumbar region throw a severe strain on the lumbo sacral region generally and on the sacro iliac joint particularly. When the lumbar lordosis is increased the body weight is transferred to the sacrum not through the body of the vertebra but behind that by way of the spinal arch. The long slender type of back is unable to withstand this strain for any length of time and at least one large industrial company refuses to employ for hard labour any man over 5 feet 10 inches in height but tries to obtain men of about 5 feet 8 inches high with a square stocky back.

Postural strain is precipitated by certain occupations. Surgeons and dentists who have to bend over their work for long periods are especially liable. It is useful to remember in this connection that the backache produced by bending over one's work can be relieved almost immediately by placing a stool under one foot. The elevation of the one foot tends to straighten out the lumbar region and so relieve the strain.

One of the common causes of chronic strain in the lower back is a sagging or protuberant abdomen which by its weight and its downward and forward pull tires out the muscles and leads to increased tension on the ligaments supporting the lumbar spine.

The obvious treatment of such a condition is reduction of weight and therefore of the size of the abdomen by dietetic methods combined with active exercises designed to increase the tone and control of the abdominal muscles. Failing this, the strain may to some extent be relieved by supporting the abdomen. In fitting abdominal supports it should be borne in mind that the strain is not diminished if the belt is of equal width at the back and at the front. To be of real benefit the support should extend well above and well below the lumbar spine while its abdominal width must be greater than that at the back.

Many cases of chronic back strain are caused by deformities of the feet or the knee. The feet, therefore, should be carefully examined and abnormalities such as flat foot or valgoid deformity corrected.

5 Low Back Pain referred from Other Regions

Under this heading Osgood discusses four types of error which may cause backache.

(i) General debility and mental or physical fatigue

(ii) Gynaecological and genito-urinary lesions. At one time the tendency was to look on disorders of the pelvic viscera as supplying the key to all these problems. Inflammation of the ovaries and tubes, and displacements of the uterus, were considered the common, if not the sole cause of low back pain in women. The perfection of the X-ray apparatus together with the realization that low back pain is as common in men as in women, has proved how fallacious was the old assumption of the visceral origin of these symptoms.

Renal calculus may give rise to acute lumbar pain without showing the characteristic radiation of renal colic. The writer recently treated such a case of renal stone, accompanied by periodic attacks of backache. The main complaint was pain in the back, there was no indication of any abnormality in the urinary tract. In fact the attacks usually came on after hunting. The X-ray examination disclosed a very small stone in the left kidney, the removal of which completely relieved the backache.

Retroversion of the uterus, particularly before the menopause has been associated with backache. This is relieved in a large percentage of cases by the necessary gynaecological treatment.

Constipation as a cause of low back pain may easily be overlooked unless the possibility is borne in mind. It has been pointed out that an overloaded colon in addition to the backache it may produce in virtue of its weight and of the toxins it may feed into the circulation, may also cause backache from pain referred along the distribution of the lumbar nerves.

(iii) *Neurological Lesions—Spinal Cord Tumours*. Osgood points out that there is a small, but definite group of cases where the symptoms are suggestive of an organic lesion, which is liable to be overlooked. Lumbar puncture in combination with puncture of the cis

terna magna, may reveal a complete spinal block, or the fluid obtained may show definite change either in tension or in constitution

(iv) *Imperfect Mechanical Conditions in the Lower Limbs*, especially faulty posture of the feet This has been referred to under the static or postural type of backache It is a common contributory, and occasionally a primary, cause of back pain

6 Low Back Pain from a Combination of Causes

This is probably the most important feature in difficult and persistent cases Numerous combinations occur as for example, postural strains in susceptible bodily form with or without anatomical abnormalities on which is so commonly superimposed fibrositis, or postural and traumatic strains superimposed on a pre existing arthritis Such a combination of errors demands a combination of methods of treatment

Summary

The essence of the diagnosis of low back pain lies in a careful history and in a painstaking examination The decision can be accurate and the treatment intelligent only if we have in addition, an accurate anatomical knowledge of the part involved Judgement and ability are also necessary in estimating the extent to which static or anatomical factors are responsible for the symptoms

Good X ray films are the most valuable confirmatory evidence Their interpretation should be undertaken only by one familiar with the chemical picture

Sciatica

Sciatica as expressed in the modern attitude signifies sciatic pain without counting any particular pathogenesis Essential sciatica, or sciatic neuralgia should be differentiated from a sciatic neuritis or a true inflammation of the nerve

An inflammation of the sciatic nerve may be either primary or secondary Primary sciatic neuritis is due to a generalized toxæmia, as from alcoholism or lead or arsenic poisoning or it may be the result of systemic disease, such as diabetes or syphilis The secondary form is likewise a peripheral neuritis, but it is due to pressure on the nerve, usually before it leaves the pelvis, as from a spinal cord tumour that exerts pressure within the canal, or metastatic tumours that press on the root, plexus or trunk Pelvic tumours may give unilateral pain from pressure on the plexus or nerve

The reflex neuralgias, however, are of much more frequent occurrence than those two groups combined Before a reflex sciatica can be diagnosed sciatic neuritis must be excluded Unlike the latter the neurological manifestations in reflex sciatica are normal Sciatica is usually preceded by symptoms of muscular insufficiency in the lumbar and sacro iliac regions—intermittent ache and tiredness, stiffness and soreness, boring pain over the lumbo sacral or sacro iliac joints Muscle

spasm in the lumbar area and a protective list may be present. In many of the cases there are signs of generalized nervous fatigue and irritability. The frequency with which weak feet and varicose veins accompany the neuralgias is regarded as further proof of the presence of physical strain.

The chief symptom is pain either sudden or gradual in onset. It is gnawing or burning and may be continually present or may occur in paroxysms. It is often extremely severe especially at night. It is worse in any position that causes pressure on the nerve such as sitting. The patient in bed lies on his side with the hip and the knee bent and the ankle plantar flexed. The pain begins in the lumbar region or in the hip joint and tends to spread downwards. It may never reach below the knee and is generally worse at the back of the hip and thigh but it may involve any or all branches of the nerve in its course. Special points of tenderness known as *Vallais's points* are found on the nerve and its branches between the ischial tuberosity and the great trochanter at the centre of the posterior aspect of the thigh just lateral to the middle of the popliteal space the middle of the calf and lastly just behind the medial malleolus.

Lasegue's sign is present in all cases. If the knee is kept in full extension and the foot dorsiflexed the hip cannot be flexed to any extent without causing great pain this being brought about by the direct stretching of the nerve.

To avoid stretching the nerve the patient in a severe case walks on the toes of the foot of the affected side with a plantar flexed ankle the hip and knee being kept flexed. The knee jerk may be diminished or absent. Scoliosis is often produced and there may also be paræsthesia or hyperæsthesia. Gluteal atrophy is often present and X-ray frequently reveals arthritic changes.

DIAGNOSIS

In all forms of sciatic pain a full investigation should be carried out. Where a tumour is exerting direct pressure on to the nerve cord etc. i.e. in the spinal canal a bilateral sciatica may develop. This is exceedingly rare in other circumstances. Secondary carcinoma subsequent to a breast or thyroid gland operation has a special predilection for this site and inquiries should always be made with regard to previous operations. Diseased kidneys or prostate gland ovarian or fibroid tumours or infected sacro iliac joints and lumbar spondylitis may not infrequently give rise to a form of sciatica to be diagnosed only by a thorough examination including rectal and X-ray examinations. It is wise also to exclude the lightning pains of tabes and transverse myelitis before embarking on treatment.

TREATMENT

If any specific cause can be discovered the primary treatment will naturally be directed towards this. Palliative treatment however, in

such a case is not to be despised. The bowels should be well cleared out while Pemberton recommends a restricted diet giving a minimal caloric intake from the outset. Rest however must be the basis of treatment in sciatica as in all other cases of acute inflammation. Local treatment in the form of dry or moist heat is the next indication. Dry heat by a radiant heat lamp or a Q ray pad if not successful is replaced by moist heat. Mud packs are probably the best form in which to apply moist heat and the simplest method is to apply according to the directions on the prepared packs procurable through most chemists. The old fashioned mustard pack is also very helpful.

Counter irritation in the form of tincture of iodine turpentine or A B C liniment is useful but if not powerful enough Thermogene wool which has been dampened with either water or ether may be used as a second line of attack but being very irritant should not be applied for long. Electrical treatment is often disappointing. Diathermy sometimes benefits but often exacerbates the condition. Ionization may be of help in the more acute forms. Massage is contra indicated in the acute stages later it is valuable especially if the condition is fibrositic in origin. Aspirin takes pride of place as in all other rheumatic conditions as an analgesic. Amongst substitutes may be mentioned pyrimidon novalgin phenacetin and vegamin. In the later stages iron and arsenic or strychnine is desirable as sciatica wears the patient to a surprising degree. At the same time and especially in those cases showing muscular insufficiency graduated exercises are prescribed.

In recent cases secondary to an acute attack of fibrositis a dramatic relief of pain may follow the accurate injection of the fibrositic nodules (see Fibrositis).

Although stretching of the nerve is contra indicated in acute sciatica old standing cases of neuritis associated with chronic fibrositis frequently benefit from manipulation of the back and thorough stretching of the sciatic nerve under anaesthesia followed by progressive active exercises.

The Ober Operation for Sciatica Ober of Boston has obtained good results in certain cases of sciatica by an operation whose principal procedure is section of the ilio-tibial band if that band is contracted. He believes that before this operation is carried out there are several important diagnostic points to determine the presence of contraction.

1 Straight leg raising is usually limited whether sciatica is present or not.

2 When these patients are asked to sit and bend the body forward with the legs extended it is very rare for the lumbar spine and pelvis to flex to even a right angle.

3 The most important diagnostic sign of the contracture is obtained as follows. The patient is placed directly on his good side. The examiner places one hand on the pelvis to steady it and grasps the

patient's ankle lightly with the other hand holding the knee flexed to a right angle. The thigh is abducted in the coronal plane of the body. If a contracture is present the leg will remain abducted the degree of abduction depending on the amount of contracture present. This sign is present in both the conscious and anesthetized patient. If there is no contracture present the thigh will adduct beyond the middle line.

The treatment of this condition resolves itself into one factor, and that is the relief of the contracture. In suitable cases the operation is performed as follows:

1. An incision is made from just below the crest of the ilium down to the tip of the trochanter directly over the contracted ilio tibial band.

2. The fascia latae is exposed forwards as far as the anterior superior spine and backwards to the edge of the gluteus maximus muscle. The area of the greatest contracture of the fascia can be seen readily and felt easily.

3. The fascia is now divided transversely from just below the anterior superior spine to the anterior border of the gluteus maximus muscle. There is immediate separation of the cut edges for a distance of three fourths to one and a half inches depending upon the amount of contracture present. If the operator now attempts to carry out the test described above it will be shown that the thigh will adduct completely.

Heyman recommends the sub periosteal stripping of the upper portion of the gluteus maximus muscle (that part inserted into the fascia latae) and the iliac attachment of the short and long posterior sacro iliac ligaments from the postero superior spine of the ilium. He believes this may relieve pain in two ways: (1) by releasing the tension of the muscle and the strain at the site of the muscular and ligamentous attachments, and (2) by relieving muscle spasm.

Protrusion of an Intervertebral Disc

It has become widely recognized in recent years that retropulsion of an intervertebral disc previously thought to be a condition of some rarity is a relatively common cause of intractable sciatica.

All cases of severe sciatic pain of long standing demonstrate reduction of movement in the lumbar spine, limitation of straight leg raising and diminution or even absence of the ankle jerk. This diagnosis therefore must not be made until all possible causes of low back pain and sciatica have been eliminated. There is no single symptom or sign from which the diagnosis can be made. It depends on a careful analysis of the history in association with meticulous clinical examination.

PATHOLOGY

The pain in the distribution of the sciatic nerve is directly due to pressure on one or more parts of the cauda equina by the protrusion of the intervertebral disc. The lesion is found most commonly in the

fourth or fifth lumbar discs which as a result of trauma to or degenerative changes in the annulus fibrosus protrude laterally and compress the nerve root immediately before its exit through the intervertebral foramen. The nerve root is flattened at the point of pressure and the area immediately proximal is oedematous and injected.

DIAGNOSIS

The history is that of intractable sciatic pain immediately following a lifting injury or with an intervening latent period. Coughing, sneezing or straining increases the radiating pain.

On examination it is noted that the patient suffers from a sciatic scoliosis, the lumbar curve is reversed and all movements of the lumbar spine restricted. Tenderness may be present between the fourth and fifth lumbar spines or at the lumbosacral junction and straight leg raising is markedly limited. Wasting of muscle is present in the buttock, thigh and calf and the ankle jerk diminished or absent.

In a proportion of cases weakness of the dorsiflexors of the foot may be demonstrated. In some cases sensory changes are present in the leg but the localization of the lesion from consideration of the sensory changes proves unreliable as the distribution of radiating pain does not correspond to the sensory dermatomes.

Lumbar puncture is carried out at the lowest possible level, preferably at the lumbosacral junction. The information to be gained from this procedure is of value in eliminating other causes of pain in the sciatic distribution because according to some authorities there is a raising of the total protein though the figures given by authorities vary so widely that its importance cannot be stressed.

Routine radiological examination of the lumbar spine and sacroiliac regions eliminates other possible causes of the symptoms but is of little value in making a positive diagnosis although narrowing of the space between the fourth and fifth lumbar vertebrae—an uncommon finding—may be considered to be confirmatory. Lipiodol myelography yields most valuable information but the risk of arachnoiditis from the irritating effects of this medium is so great that until a more innocuous contrast medium is available its use is unjustifiable. Air or oxygen myelography has unfortunately proved unreliable.

In the light of our present knowledge it is evident that the diagnosis of this condition depends more on clinical experience in the interpretation of the history in association with symptoms and signs than upon X-ray examination and laboratory tests.

TREATMENT

Conservative Treatment The rationale of conservative treatment is the reduction of irritation of the nerve root or roots by immobilization of the lumbar spine and is worthy of trial in all cases except those exhibiting obvious signs of serious root pressure indicated by sensory and motor disturbance. A light close fitting plaster jacket of

similar type to that used for fractures of the spine is applied and the patient treated by rest in bed. Patients who do not show satisfactory relief of pain within a few weeks usually require operation.

Operative Treatment. Operative treatment is indicated in cases which show anæsthesia, muscle weakness or paralysis or other sign of severe root pressure, and in cases which have failed to benefit from or have relapsed following conservative treatment.

The technique of operation has been modified in the light of experience. Partial laminectomy in which the adjacent portions of two laminae are removed, but the continuity of no whole lamina is sacrificed is now considered to give sufficient exposure for the excision of the protruded disc. More recently the fenestration technique with excision of the ligamenta flava only has been practised.

When a more radical exposure, necessitating the sacrifice of laminae and an articular process, is required, the subsequent weakness and pain in the low back can be avoided by the insertion of an Albee type graft supplemented by bone chips at the original operation.

Kummel's Disease

Kummel's disease may be defined as a crumbling collapse of a vertebral body following an injury. For some time after a direct or indirect spinal injury the patient may be incapacitated by the bruising, by diffuse or localized pain, or even in severe cases, by girdle or limb pain. Slight muscular weakness may be apparent in the limbs, or all the evidence of a more severe paralysis be present. After varying intervals, these symptoms subside, and the patient is apparently well enough to resume his ordinary occupation. Weeks, or even years, after, the pain returns, accompanied, it may be, by symptoms referable to interference with the spinal cord. Clinical examination may reveal the existence of an actual spinal deformity, which may even take the form of an angular kyphus.

The course of the disease is usually divided into five stages.

(1) *The Injury* The injury varies in type, and in severity. It may be a direct blow on the back, as when a man is struck by a fall of stone from the roof, or it may be an indirect injury, like that sustained by falling from a height and landing on the heels. In many cases there may be no demonstrable lesion at this stage. If there is any evidence of damage to the vertebra it is usually in the anterior part of the body.

(2) *The Post-traumatic Interval* The injured person may be confined to bed for some time, because of the contusion, he may even be paraplegic. Not infrequently, however, he is perfectly well, and immediately able to go about as before.

(3) *The Latent Period* An interval of days, weeks, months, or years, follows, during which the patient is not conscious of any abnormality, he may even have resumed heavy work.

(4) *The Return of the Symptoms* The individual then begins to

complain of symptoms at first local consisting of pain tenderness and weakness at the site of the original injury. Later any degree of paralysis may appear.

(5) *The Healed Stage* If the patient is effectively treated and the collapse of the vertebral body arrested the prognosis is good. Without treatment the disease progresses until eventually the collapse is extreme and a well marked deformity is present. At this stage the spinal cord is liable to be severely crushed.

Any part of the column may be affected. In Kummel's original paper the lesions occurred from the third to the eighth thoracic vertebra but cases have been recorded in which the twelfth thoracic and first lumbar have been the site of the disease.

Etiology

Kummel at first believed that the process was inflammatory of the nature of a rarefying osteitis superimposed on some nutritional disorder. Later he came to the conclusion that the damage to the vertebral body was always effected by the original injury.

It is now generally held that repeated minute injuries to the bones and ligaments of the spine cause small cracks and hæmorrhages. The nutrition of the vertebral body is thus interfered with and a secondary collapse ensues.

It is quite likely that the condition is a crush fracture with little or no displacement so that it is unrecognized. Thereafter weight is borne on it too soon so that it collapses.

DIAGNOSIS

The diagnosis rests upon the X ray picture especially the lateral view. The appearances in the later stages are distinctive although immediately after the injury the radiograph may be inconclusive.



FIG. 29 —Kummel's Disease of the Spine

The disease has to be carefully differentiated from Pott's disease, and, although this may appear difficult, there are certain distinguishing features. In Kummel's disease the patient is usually a healthy workman. There is no evidence of abscess formation and the radiological examination shows a wedge shaped vertebra with, possibly, a fracture. The edges, however, are clear, and the intervertebral discs intact.

TREATMENT

Immobilization in the recumbent position, essential for the relief of the crushed body from superincumbent pressure is admirably obtained by rest in a bed fitted with fracture boards. The deformity may be gradually reduced by rest in the supine position on a firm pillow inserted beneath the site of angulation. When the maximum reduction of the deformity has been obtained a plaster jacket is applied using the suspension method of Davis to obtain hyperextension and further reduction of the deformity. When the plaster jacket has been applied the patient may resume ambulatory treatment carrying out supervised exercises of the type used for recent fractures of the spine. These exercises form an essential part of the treatment and must be carried out conscientiously throughout the whole period of immobilization. The plaster jacket is retained for 6 months.

Many of the cases are best treated by a spinal bone graft inserted after the method of Albee. The operation is performed after the period of recumbency and only when the maximum reduction has been obtained. By these means the period of disability may be shortened and the relief of symptoms assured.

Calve's Disease of the Spine

This condition of the vertebral body is of the nature of Perthes disease of the hip and though by no means common is a very definite entity and easily recognizable in the X ray film. It was first described by Calve in 1924 when he showed two cases at the meeting of the British Orthopaedic Association.

It is usually diagnosed at first as a tuberculous lesion. The condition is usually in the dorsal region and occurs at an early age. Calve's original two cases were in children of $2\frac{1}{2}$ and 7 years of age. The onset is insidious though there may be a history of slight injury. There may be pain, local or referred, occurring spontaneously or only during exercise. A small gibbus may be present and local tenderness may be elicited by percussion over the affected region. Spinal rigidity is usually present in the early stages and night cries may be present. Apart from a possible negative tuberculous reaction the clinical picture may well be that of an early spinal caries. The progress is, however, uncomplicated by abscess formation or paraplegia and no gross deformity ever occurs. The prognosis is good.

On X ray examination only one vertebra is usually affected and the discs on either side are intact. The body of the vertebra is reduced to

a thin disc of increased density very like a Kohler's disease of the tarsal caphoid. Regeneration of the vertebral body occurs to a considerable degree although the body never resumes its normal size. Dale points out that it is not to be confused with what he calls lamellar tuberculosis, where two flattened and fused tuberculous bodies may simulate Calve's disease. This fusion is easily recognized by the presence of two neural arches attached posteriorly to the fused mass.

Treatment is on the lines of that adopted for a tuberculous lesion—traction in hyper extension and later immobilization and protection. The period of treatment however is much shorter than that for tubercle.

Scoliosis

Scoliosis or rotatory lateral curvature of the spine, is a deformity of the trunk characterized by a permanent deviation of one or more segments of the spinal column from the mid line of the body, the deviation is invariably accompanied by some degree of rotation. The deformity involves alterations in the relative positions of the ribs and pelvis and adaptive changes in muscles and ligaments. The most important factor of all however is the disturbance of the automatic reflex action of the muscles which are responsible for the maintenance of the normal posture of the body. The lungs may be compressed giving rise to dyspnoea or the abdominal organs may be so displaced that gastro intestinal disturbances arise.

Scoliosis therefore should be regarded as a deformity of the spine which secondarily affects the entire trunk.

Occurrence Scoliotics are frequently seen among the hospital classes but are considerably less common in private practice. Schanz found that 7 per thousand of the recruits for the German Army—less than 1 per cent—were disqualified because of spinal deformity.

At school age, scoliosis is more frequent in boys but in adolescence girls are most affected. The difference at the two age periods is difficult to explain, but it may be that boys outgrow scoliosis as they become stronger or that girls are conscious of slighter degrees of curvature, and so come up for treatment when the opposite sex would ignore the deformity.

Terminology Various terms are used to describe the deformity and these may now be defined. The curvature is spoken of as right or left, according to the side of the convexity. It is also named according to the anatomical region involved so that we get a right thoracic 'left lumbar,' and so on. Curves may be referred to as being primary or secondary. Sometimes, however, it is impossible to decide in what order they have arisen. The single curve is also occasionally called a C-curve, and a double curve an S-curve.

Classification

There are two types of scoliosis

- 1 *Functional* or postural, scoliosis
- 2 *Structural*, rigid or fixed scoliosis



FIG. 233.—Functional Scoliosis

A total C curve to the left

The distinction between the two is definite and is based on differences in their pathology

Functional Scoliosis. The functional curve is one which the child can correct voluntarily. It is particularly common in children of school age and results from the habitual assumption of some faulty attitude or posture. The extent of the deformity is invariably within the range of normal spinal movement but it assumes great significance when it is so frequently adopted or maintained for such long periods that it becomes habitual or permanent. Structural changes occur only in the late stages, they are compensatory, and essentially similar to the secondary changes which follow the structural type. When definite architectural changes occur in the course of a functional scoliosis, the case may then be more properly regarded as a rigid or structural scoliosis.

In about 90 per cent of the cases the curve is to the left and is a complete total single or C curve. The degree of deviation from the middle line is usually slight and varies from $\frac{1}{2}$ to 1 inch, it may even be so mild as to escape detection.

The typical features of a left total scoliosis are as follows

- 1 A general curve convex to the left
- 2 Elevation of the left shoulder
- 3 Backward displacement of the right shoulder girdle and forward displacement of the left
- 4 Undue prominence of the right side of the back when the patient bends forward
- 5 Exaggeration of the hollow at the waist-line on the right side

Since functional scoliosis is an expression of weak musculature, and of faulty posture it follows that it is frequently associated with other evidences of muscular weakness such as round shoulders, relaxed abdomen and weak feet. It occurs as frequently in boys as in girls. Schanz believes that only 2 or 3 per cent of the functional type become structural scoliotics.

Structural Scoliosis. The rigid or structural type presents a completely different picture. The trunk is grossly misshapen, the spine is deviated, there is a difference between the levels of the shoulders and one hip is more prominent than the other. There is also an obvious degree of chest asymmetry, apparent both anteriorly and from behind. The patient is quite unable to correct the deformity voluntarily, since

the distortion is due to structural alterations in the vertebræ ribs ligaments and muscles and is therefore permanent

Structural scoliosis varies in degree from a gentle convexity to a sharp angulation known as 'razor back'

The most characteristic feature is the backward projection of the ribs or lumbar transverse processes in the affected region. This is the result of the rotation of the vertebræ. The vertebral column is curved in the antero-posterior plane and since it is a flexible weight bearing rod it cannot yield in another plane without its constituents at the same time undergoing some rotation. The vertebræ in consequence turn away from the area of maximum stress which is on the concave side of the lateral curve. The bodies are therefore rotated towards the side of the convexity.

ETIOLOGY

A variety of factors may lead to the production of scoliosis and classification is accordingly difficult. Indeed in the majority of cases no definite cause can be assigned. Kleinberg believes that 80 to 85 per cent of all cases are incapable of explanation.

Baum believes that scoliosis is usually due to some congenital anomaly and that although most of the cases come under observation only about the age of puberty they are really delayed congenital scoliotics the causal lesions being present at birth although their effect only becomes obvious at this period.



FIG 94—Scoliosis lateral Curvature produced by an old empyema scar

Fraser stresses the importance of the lateral spinal muscles in the production of the error. He points out that the stability of the spine is secured by a number of arrangements:

- 1 The method of articulation between individual vertebra
- 2 The stay influence of the long spinal muscles
- 3 The supporting influence of the ribs which extend between the spine and the sternum
- 4 The equal distribution of weight through the shoulder and pelvic girdles
- 5 The multiplicity of short muscles and ligaments which fasten the individual bones together

The long spinal muscles are capable of two kinds of muscular activity—the activity of movement, phasic and intentional and the activity of posture, that prolonged and partly involuntary exercise of function which we sometimes speak of as “tone” According to Fraser, it is most likely the tonic or postural function of the long spinal muscles which maintains the spinal column in its normal attitude of extension—the erect posture It is a natural corollary, therefore, to assume that an error in this mechanism may result in unilateral weakness and subsequent deformity He thus explains the etiology of the postural type of scoliosis and points out that its first appearance is generally coincident with the school age of life, and especially with the period when the strain of mental work is first beginning to be appreciated

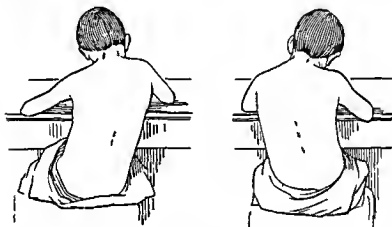


FIG. 290.—The effect of a lazy attitude in the acquisition of a Postural Scoliosis

McLennan of Glasgow on the other hand believes the deformity to be due to a primary error in the growth of the bones of the spinal column

Jones and Lovett classify scolioses as follows

(1) *Congenital Scoliosis* a type due to congenital malformations of the spine the scapula or the thorax, to some deforming intra uterine pressure or to a paralysis of ante natal origin

(2) *Acquired Scoliosis*

(a) Anatomical or physiological, due to asymmetries elsewhere than in the spine This group includes torticollis pelvic asymmetry, pelvic obliquity, e.g. from a short leg and irregularities of vision and of hearing

(b) As a result of pathological affections of the vertebrae This group includes rickets, osteomalacia tuberculosis dislocations fractures, arthritis deformans, and tumours

(c) As a result of pathological affections of the extremities which cause asymmetrical postures In this group are included diseases of the bones and joints of the legs or arms

(d) Following diseases of the soft parts This group includes infant

tile paralysis spastic paralysis nervous diseases empyema organic heart disease scars gross abdominal or pulmonary disease acute or chronic inflammation of the soft parts in relation to the spine

(e) As a result of habit or occupation The commonest cause of this occupational or postural scoliosis is the assumption of faulty attitudes by children both at school and at home Violin playing the use of the side saddle in riding the carrying of heavy weights with one arm poor school surroundings bad school furniture and twisted positions while writing all induce faulty attitudes and may thus produce severe curvatures of the spine

PATHOLOGY

Changes in the Vertebrae The vertebrae at the apex of the curve are compressed to a wedge shape and are called the wedge or apical vertebrae The thinnest part of the wedge is on the side of the concavity and generally towards the posterior aspect of the body In severe cases the side of the body towards the concavity is lipped and synostosis may occur between adjacent wedge vertebrae In addition the vertebrae as a whole are rotated towards the side of the convexity

The bones above and below the apical vertebrae also show characteristic distortions in that they are twisted on their vertical axis to form the so called lozenge shaped vertebrae In the thoracic region the spinous processes are deflected towards the convexity of the lateral curve

The intervertebral discs show early changes and at the points of maximum curvature are compressed and squeezed out beyond the edges of the vertebral bodies

The ligaments on the side of the concavity are dense and thick on the convex side of the curve they are thin and lack a definite lateral border The muscles on the convex side are also atrophied and show fatty or fibrous degeneration on the concave side they are hypertrophied

The Thorax In thoracic scoliosis the thorax is not only displaced as a whole towards the side of the convexity but is also distorted It undergoes a twist in a direction opposite to that of the spine so that its horizontal diagonal is altered In a right thoracic scoliosis the ribs on the right side are brought nearer the front of the vertebral bodies and the capacity of the right side of the thorax is thus seriously diminished The posterior parts of the same ribs are more angled than normally

The development of the internal organs is prevented and their functional activity seriously impeded since the pleural and abdominal cavities are both deformed Anaemia is occasionally present and there is an added liability to pulmonary disease The heart is frequently displaced upwards and for vards against the anterior chest wall commonly it is hypertrophied and dilated

GENERAL SYMPTOMS

Unless there is some co existing condition, patients with scoliosis are of good colour, feel well, and suffer little inconvenience. They are usually able to attend school, and their physical development is nearly equal to that of a normal child.

Advice is usually sought because of some outstanding feature, such as a high shoulder, high hip, prominent shoulder blades, or a sunken waist line. Often the dressmaker is the first to notice some inequality of the hips. *occasionally the observant parent notices the spinal curvature and seeks advice for that reason.* In all cases the deformity is usually well established before treatment is sought.

Older children often complain of pain, but this is rare under the age of 10. It usually takes the form of a mild backache, which is increased on exertion. After the child has started to work he often complains of great exhaustion at the end of the day.

In severe cases, when the chest has become greatly deformed and sunk towards the pelvis, severe pain may arise from the pressure of the lower ribs against the iliac crests. *Occasionally, too, referred, or root, pains are experienced in the limbs, chest, or abdomen.* In these cases the pressure on the nerve roots results from the distortions of the intervertebral foramina.

If the abdominal organs have been crowded down by the ribs, symptoms referable to gastro intestinal disturbances may arise, and, if the chest capacity is much reduced, there may be dyspnoea and tachycardia, especially on exertion. At a later stage of life painful secondary arthritis of the spine arises.

Although many of the patients are able to go through life with little or no trouble it can generally be predicted that a curve of moderate severity will become progressively more troublesome in later adult life.

Scoliosis in Various Regions

Thoracic Curve The curvature is usually to the right and some, *or all, of the thoracic vertebrae may be involved.* There is usually a slight compensatory curve in the opposite direction, either above or below the thoracic curve, or both. Viewed from behind, the right shoulder is higher than the left and the right scapula so elevated and rotated that its inferior angle projects and is situated much further away from the mid line than on the left side. The ribs on the right side are prominent project backwards, and their angulation is decidedly increased. Their downward inclination is greater and the intercostal spaces wider than normal. The right arm hangs away from the body and is further from the mid line than the left. There is usually a transverse furrow or crease at the junction of the chest and lumbar region *on the left side while on the right side, the normal contour of the waist line is either entirely obliterated or considerably filled out.*

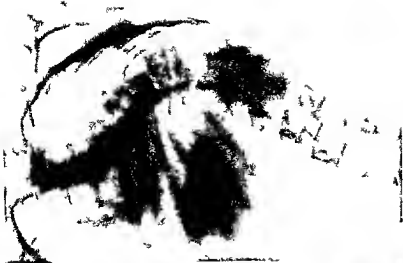


FIG 298

FIG 298—Scoliosis—Congenital abnormality of the cervical vertebrae

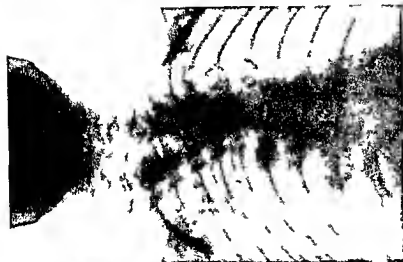


FIG 297

FIG 297—Scoliosis—Congenital abnormality of the thoracic vertebrae



FIG 296

FIG 296—Scoliosis—Congenital abnormality of the thoracic vertebrae

The left shoulder is low and is situated on a more posterior plane than the right. The left side of the chest is flattened, and a groove runs downwards and laterally below the scapula. The flattening of the chest on the left side is accentuated by raising the arm. In some cases the left chest is actually hollow, the deepest part of the hollow being opposite the summit of the concavity. The ribs are flattened and very closely placed while the waist line is always exaggerated and the iliac crest unduly prominent.

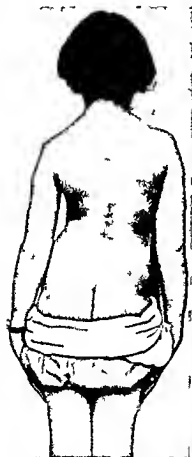


FIG 299—Scoliosis. A mild degree following Poliomyelitis.

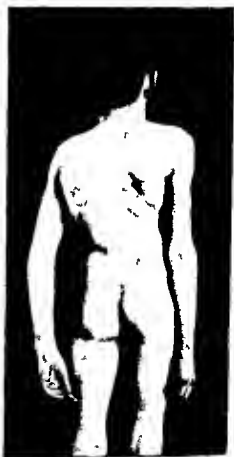


FIG 300—Scoliosis. A severe degree of the deformity following Poliomyelitis.

When the patient bends forward, the posterior projection of the right ribs—the rib 'hump'—is rendered more prominent, as is the asymmetry of the back.

The marked asymmetry of the chest is also apparent from the front. The right side is now flattened and the left ribs projecting. The left costal margin is very prominent and frequently everted, the sternum may be rotated on its vertical axis, so that the left border lies more anteriorly than the right.

In antero posterior radiographs when the curve is limited to the thoracic region the shape of the spine can be aptly likened to that of a question mark. The two vertebrae at the apex of the curve are wedge shaped their bases being to the right. The abnormal position of the spinous processes and the appearance presented by the articular facets are evidence of the rotation of the vertebral bodies. The right costal facets since they present the larger surface to view appear bigger than the left.

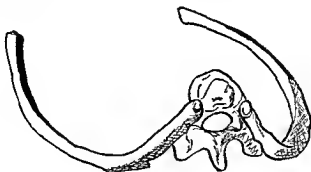


FIG. 301.—Scoliosis. The chest deformity.

Lumbar Curve. Here the deformity usually involves only the lumbar spine and the hips the chest and shoulders remaining practically normal. The curve may thus be likened to an inverted question mark.

The apex of the curve is at or about the third lumbar vertebra. In a left lumbar scoliosis in which the lumbar spine is convex to the left the most noticeable feature is the prominence of the right iliac



FIG. 30.—Scoliosis. Severe degree of razor back.



FIG. 303.—Scoliosis. Mild degree of razor back.



FIG 304.—Scoliosis. Severe deformity in a boy of 10. The convexity carried the arm away from the body.

crest when viewed from behind. On the right side the waist line is exaggerated while on the left side it is usually obliterated. The left loin projects backwards and is more prominent than the right since the rotation of the vertebral bodies to the left causes the transverse processes to become more prominent. The left loin is also firmer and more resistant to touch, the right side being soft and yielding. The pelvis is usually tilted downwards on the left side and the left iliac crest is therefore on a lower plane. There is frequently some inequality in the lengths of the lower limbs and on the side of the convexity of the curve the leg may be as much as $\frac{1}{2}$ to 1 inch shorter than its fellow.

When the patient bends forwards the upper part of the back is symmetrical but in the lumbar region the left side projects upwards while the right side is flat or even hollowed.

Viewed from the front the left anterior superior iliac spine is lower than the right even when the legs are of equal length. When the patient is seated however the anterior superior spines are on the same level.

In an antero-posterior radiograph the lateral deviation of the lumbar section of the spine is very evident. The spinous processes of the lumbar vertebrae which normally show up opposite the middle of the vertebral body

now lie to the right and may even be opposite the right border of the body. The right articular processes are not usually visible while the left processes are seen to lie to the right of the left border of the bodies or even opposite the middle of the bodies. The left transverse processes are more clearly and more completely seen. The pelvis may be entirely normal and the sacrum is usually unaffected though occasionally it is asymmetrical with its right side contracted and distinctly smaller.

Thoraco-lumbar Curves. In these curves the point of maximum deformity is usually situated at the thoraco-lumbar junction and extends from about the third or fourth thoracic to the third or fourth lumbar vertebrae. Lateral deflection is usually greater than rotation and the convexity is usually to the right. In the majority of cases compensatory curvature does not occur although careful radiographic examination occasionally shows a slight curve in the opposite direction of the upper thoracic and lower cervical vertebrae.

If a case with convexity towards the right be viewed from the

back the whole trunk appears to be displaced to the right, and when a perpendicular line is drawn upwards from the natal cleft the lumbar and thoracic regions and sometimes the head will be found to be to its right. The right shoulder is high, and the scapula elevated and rotated laterally from the mid line, so that the inferior angle is very prominent. On the right side the ribs project backwards, the arm hangs farther away from the side, the waist line is obliterated, and the hip is flat. On the left side the shoulder appears relatively low, the waist-line is exaggerated, and the hip prominent. A furrow extends from the spine downwards and laterally below the left scapula, giving the left chest a flat or hollow appearance. The downward inclination of the ribs is greater and the intercostal spaces wider on the right side. When the patient bends forwards the back is asymmetrical, for the right side is convex from the upward projection of the ribs whereas the left side is flat or concave.

From the front the deformity is just as marked as from behind. The whole trunk is deviated to the right, and the right shoulder is higher than the left. The left hip is more prominent, and the waist-line markedly exaggerated. The chest is flattened on the right side and prominent on the left, so that in girls with well developed breasts the left breast may appear the larger. The lower ribs on the right side may be close to, or even lower than, the iliac crest so that the lower part of the abdomen is compressed and made to bulge. The anterior superior iliac spines are usually at the same level.

An antero posterior radiogram demonstrates the primary and any secondary curves. The characteristics of the vertebrae are similar to those already described.

The mobility of the spine depends on the severity of the case. In mild and moderate degrees the lateral curvature can be reduced by suspension or manipulation, but in the severe types the thoracic spine becomes so fixed that manual pressure fails to correct the curvature. Flexion and extension are comparatively unaffected.

DIAGNOSIS OF SCOLIOSIS

A lateral curvature occurring before puberty and not associated with pain suggests a diagnosis of scoliosis. When scoliosis is present it must be decided whether it is postural or structural in origin, and the exact type of curve must be defined. In each case a definite cause should be sought in view of the bearing it will have on the treatment of the error.

DIFFERENTIAL DIAGNOSIS

1. **Pott's Disease.** Lateral deviation of the spine may occur in the acute stage of Pott's disease, but the pain on movement and the loss of spinal mobility, the elevation of temperature, and the impairment of general health, are all absent in scoliosis.

2. **Arthritis Deformans.** Occasionally a lateral deviation of the spine occurs in arthritis deformans, but, although not unknown in

children, this is more usual in adult life. The spine is then stiff and painful, and the anterior lumbar convexity is diminished or lost. The lateral curvature is a gradual one, with little or no rotation of the vertebrae.

PROGNOSIS

1 Without Treatment Postural curves may remain stationary through life or may increase slightly or they may gradually progress to become structural.

Structural curvatures are practically certain to become more severe, and sometimes do so with great rapidity. They may in time lead to grave deformity, and affect the general health or even threaten life by favouring the development of pulmonary diseases.

2 With Treatment If properly treated postural scoliosis should be permanently and completely cured.

The treatment of structural scoliosis is rather a different proposition. Mild degrees in young children can be cured by long continued and well executed treatment. In more severe cases though great improvement may be obtained the deformity will probably not be entirely abolished. The older the child the less favourable is the prognosis but even in old children appropriate treatment should in all cases lessen the deformity.

Scoliosis due to severe congenital defects cannot be cured, but the curvature can be improved.

TREATMENT

Treatment of Functional, or Postural, Scoliosis As the essential cause of postural scoliosis is faulty posture with structural changes in the bones or soft parts occurring as late developments treatment should be directed to the removal of any possible cause. In this respect the effect of improperly adjusted clothing which pulls unevenly on the shoulders of improper school furniture or habits such as the carrying of books on one side of long periods of reading in bad attitudes and of physical defects such as poor vision or dull hearing must all be carefully considered and their importance assessed.

If the child is pale and weak a tonic is prescribed, mental and physical fatigue are avoided and an adequate amount of fresh air and sleep insisted upon.

The corrective part of the treatment consists in the employment of gymnastic exercises which will develop the muscles of the body. The aim of the exercises is to improve the general tone and resistance of the patient by increasing the tone and strength of the muscles. Particular attention is paid to the re-education of those special muscle groups which hold the body erect and in its normal symmetrical attitude. The type, vigour and duration of the exercises are regulated according to the patient's ability to complete them without fatigue.

in addition to active muscular contraction passive stretching may be carried out to augment the flexibility of the spine

In a severe case the patient may exhibit a tendency to retain the faulty position between the exercises and it may then be advisable to supply a light temporary support such as a celluloid corset. After the condition has been corrected the exercises should be kept up for a long time—even for several years—to prevent recurrence of the trouble

Treatment of Structural Scoliosis The treatment of structural scoliosis forms a complicated problem since we have to deal with a deformity in which more or less serious and advanced alterations have occurred in the shape and internal structure of the bones the ligaments and the muscles of the trunk. The vertebrae especially have become grossly distorted and the mobility of the spinal column has been greatly reduced

The essential objects of treatment therefore are to stretch the shortened and contracted tissues to re-establish or increase the spinal mobility and to overcome the mal position and deformity of the vertebrae. Unfortunately corrective forces cannot be applied directly to the deformed vertebrae themselves and any attempt to improve them must be made by stretching the related muscles by applying pressure to the ribs or by improving the postural attitude of the trunk

Scheme of Treatment

Comprehensive treatment embraces any or all of the following methods

- 1 Gymnastics
- 2 Corrective jacket—
 - (a) McCrae Aitken type
 - (b) Abbott type
- 3 Gymnastics plus retention corset
- 4 Manipulation
- 5 Operative treatment

1 Gymnastic Exercises In the treatment of scoliosis two types of exercise are employed

(a) *Developmental or symmetrical exercises* in which the muscles of both sides of the body are used simultaneously and to an equal extent. They are performed while the patient assumes the best possible position i.e. the nearest approach to the normal position

(b) *Corrective or asymmetrical exercises* by which the muscles of one side of the body are developed more than those of the opposite side in the hope and expectation that with their hypertrophy and increased strength they will maintain the trunk in an improved position. In particular the muscles on the convex side of the back are developed. All asymmetrical exercises are performed in the keynote position in which the patient depresses and retracts the high and elevates the low shoulder and with his hand on the convex side

pushes the chest in the opposite direction to try to straighten the curve of the spine

Gymnastic treatment on the above lines has the following effects

- 1 It increases the strength of the muscles
- 2 It increases the mobility of the spine
- 3 It improves posture
- 4 It has a wholesome effect on the patient's general condition

Exercises are useful only in the mildest types of structural scoliosis and if gymnastics do not cause any improvement it must be realized either that the exercises are not being properly performed or that the error is too severe. Lovett states that progressive improvement is the only criterion of efficient gymnastic treatment

2 Corrective Jackets Before having recourse to corrective jackets the spine should be mobilized by some method of passive stretching. One of the most satisfactory ways of doing this is that devised by Lovett who uses an ordinary kitchen table to which are fitted three canvas straps working through pulleys. The patient lies face downwards with the legs hanging over the table end. One strap encircles the shoulder girdle and another the pelvis above and below the primary curve respectively and when pulled on they tend to straighten out the spine. A third strap surrounds the chest at or about the level of the deformity and traction on it in the opposite direction enhances the corrective force.

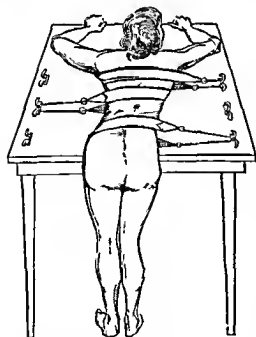


FIG. 305.—Scoliosis. Method of correcting the deformity prior to the application of an Abbott Jacket

Though passive stretching helps to reduce the lateral deviation it has little or no effect on the rotation of the affected vertebrae.

(a) *The McCrae Kitchen Jacket*

McCrae Kitchen uses a corrective jacket which he believes exerts a direct influence on the training of the patient's postural reflexes. He recognizes two distinct types of postural reflex.

1 The purely static reflex which depends on the way in which the patient balances his body weight on his feet.

2 The respiratory reflex which depends primarily on the way in which the whole thoracic cage expands and contracts during respiration.

The corrective jacket which he advises is one which

has been evolved from the suggestions of three orthopædic surgeons, Hoke, Abbott, and Haglund. Hoke pointed out that in a deformed thorax the humping portion of the chest moves more freely than the flattened portion, and that the rib when moving towards the dorsal bulge exercises a levering action on the vertebrae, and so rotates them. He believed that treatment should aim at reversing this process, and the main objectives of such treatment should be

- 1 To increase the mobility of the flattened ribs

- 2 In some measure to correct, or counteract the tendency to rotational deformity

He showed that better results were obtained by attempting to correct the rotation before the actual lateral deviation though in practice both elements of the deformity are really attacked simultaneously. He treated his patients in a plaster jacket compressing the long diagonal of the thorax. Large windows were cut out over the flattened parts of the chest to enable the flattened ribs to increase their mobility, thereby altering the respiratory movements and influencing the respiratory reflex.

Abbott stresses the importance of flexing the spinal column while the rotation is being corrected, and his jacket corrects the lumbar lordosis by flexion.

Haglund's jacket is one which primarily influences the static postural reflex and leaves the disordered respiratory reflex to be corrected partly by training and more especially by the natural effort of the patient to adjust himself to the new posture. He aims at overcoming the lumbar deviation and leaves the patient to correct the thoracic deformity for himself.

The McCrae Aitken jacket is applied with the patient on an Abbott's frame, the lumbar region being flexed to correct the lordosis. In the case of a right thoracic scoliosis, the pelvis is fixed by a lateral band which pulls to the right, while a second band at the level of the primary curve exerts traction simultaneously forwards, upwards and to the left. The flattened parts of the chest are amply padded, both in front and behind, and when the jacket is complete the pads are removed through large windows so as to leave room for expansion of the previously immobile ribs. Thereafter each inspiration helps to rotate the bodies of the vertebrae towards the mid line. A trough may be cut over the rib humps, and through it extra layers of felt introduced so as to exert an added amount of compression on the convexity.

(b) *The Abbott Jacket*

The essential features of the Abbott method of forcible correction are as follows. The patient is placed in a position of flexion on the Abbott frame. The pelvis and shoulders are fixed by canvas bands and corrective pressure exerted on the deformity by a further canvas band. The jacket is then applied in this position of flexion, and should be considerably longer on the side of the concavity. Large

windows are cut out over the flattened ribs both behind and in front and small oblong gutters are cut over the rib humps through which pads of felt are inserted to exert pressure on the bulging part of the ribs

About a week after the application of the jacket additional pads are inserted and thereafter further pads introduced up to the limit of the patient's resistance at intervals of about a week. This is the most severe part of the Abbott treatment since each pad exerts considerable pressure on the chest and produces a certain amount of pain



FIG 306 The McCrae
Aitken Jacket
(After McCrae & Aitken)

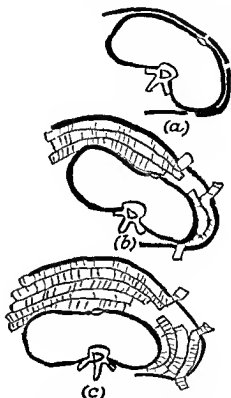


FIG 307—Method of correcting the rota-
tion in an Abbott's Jacket
Felt is placed in between the pad and the rib hump and the pad is placed in the jacket.

and discomfort. Usually from six to twelve pieces of felt can be inserted in front and half as many at the back before a new jacket need be applied. The time during which this amount of packing can be accomplished varies from a few weeks to two months depending on the rigidity of the spine and the tolerance of the patient.

During treatment the results are judged by the clinical appearance of the back and chest and by the X-ray appearances of the spine. The clinical appearance of the back is unreliable as an index of improvement in the spine because the improvement may be due to

changes in the shape of the ribs without coincident improvement in the shape or position of the vertebræ. This deceptive appearance of progress is more likely to be seen in the Abbott treatment than in the others and the most reliable evidence of the condition of the spine is the radiological examination. The degree of lateral and rotary deviation can thus be accurately observed and improvement estimated by comparing the films with those taken previously. Ordinary photographs of the patient should also be taken at regular intervals.

3 Gymnastics plus Retention Corsets Whenever the scoliosis has been corrected the plaster jacket should be discarded and replaced by a removable one and gymnastic treatment should be begun. The type of jacket now used is either a quadrilateral iron one with pelvic and chest bands or a removable turn buckle jacket.

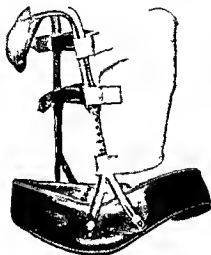


FIG 308—Scoliosis Adjustable support with canvas sling over the prominent ribs

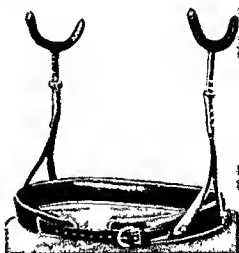


FIG 309—Scoliosis Double crutch type of support

(a) *The Quadrilateral Jacket* This jacket is usually made of celluloid or pexaloid from a cast of the patient's torso. The edges are reinforced by steel bands the lower or pelvic one passing round the pelvis the upper band encircles the chest and reaches high up under both axillæ. A further steel band passes down the middle of the back connecting the two circular supports and strengthening the celluloid. In the case of a right thoracic curve the left side is cut out to allow expansion on that side.

(b) *The Removable Turn Buckle Jacket* This jacket is also made over a plaster cast of the patient's torso. The prominence on the cast produced by the elevated scapula is cut away and the height of the plaster over the high shoulder lowered by $\frac{1}{2}$ to 1 inch. The depressions in the cast are filled up with plaster cream in order to make the torso approach more nearly the normal. The prominences which

represent the rib humps, are also shaved down with a knife, so that in the completed plaster pressure will be exerted over the convexity of the curve. A celluloid jacket is then made to fit the model, and divided into upper and lower halves, both of which are open in front to allow of their application. The jacket is then strengthened with steel bands, and the turn buckle applied, along with the necessary straps. When the turn buckle is gradually tightened the spinal curvature is straightened out by slow degrees.

Two other jackets are illustrated in Figs 308 and 309.

4 Manipulative Treatment *The Galeazzi Method of Treatment*

The latest and most successful of the forcible manipulation methods has been introduced by Galeazzi, of Milan. First of all, the rigid spine must be mobilized by a long course of manipulation and wrenching, the latter being done by the apparatus which is used for the final correction. The apparatus (which costs £200) consists of two pieces of mechanism, one of which fixes the pelvis and the other the shoulder girdle. Each of these can be rotated round a vertical or a horizontal axis. The patient stands on a platform and stoops down so that the back is horizontal, in the position of a quadruped. The pelvis is then surrounded by a plaster case which comes down to the level of the trochanters. The shoulder girdle is fixed by another plaster case. The two extremities of the spine are then flexed and rotated so as to correct the deformity as far as possible. Two bandages are passed round the trunk on opposite sides and pulled upon by assistants, so as to straighten the spine further, after which a third plaster bandage is applied to connect the shoulder and pelvic pieces. Windows are cut in the plaster jacket opposite the concavities of the curves. The plaster is worn for about three months, when it is renewed in the same manner. Cure is effected in about 12 to 36 months. Whether such a cure is permanent may be open to doubt, and Galeazzi usually employs celluloid cases for permanent wear after the cure is complete. This probably represents the best of the mechanical methods of correcting scoliosis. It is so elaborate, costly and trying to the patient, however, that it almost justifies the attitude of most surgeons and patients in considering that the disability of the deformity is better than the hardship of the treatment.

5 Operative Treatment The great majority of cases of rigid scoliosis either cannot be completely corrected, or tend to recur when ever treatment is stopped. In this event spinal fusion is indicated in order to prevent the deformity increasing. One of the chief objections to operation is that it fixes only the posterior part of the spine, but despite this it is a valuable line of treatment in carefully selected cases. Except under very unusual circumstances only adults should be treated in this way. Fusion of the spine is recommended by Jones and Lovett in patients who, on reaching adult life, seem doomed to wear jackets or some other form of heavy apparatus all their lives.

Pre operative Treatment Before operation is undertaken the de-

formity should be corrected as far as possible by other means. To secure this the patient should be kept in bed on a Whitman's frame angled at about 150 degrees, and he should not be allowed to stand up or even sit up for any purpose whatever during the entire course of the treatment. After a few days longitudinal traction is applied by means of a Sayre's balter round the head, and a canvas girdle round the pelvis a 5 lb weight being attached to each. Later the weight may be increased to 10 or 20 lb at the head and 15 to 25 lb at each side of the pelvis. The weights are released during meals and also for a daily bath and for massage. The arms, legs, and chest are quite free.

X ray pictures are taken every ten days, and it will be found that steady progress occurs up to the end of from four to eight weeks, when maximum correction may be said to have taken place.

This treatment has all the advantages of the plaster jacket method, but in contrast to the latter is almost entirely painless. When the maximum improvement has been effected, a fusion operation is carried out to prevent relapse. The best type of operation is that associated with the name of Kleinberg.

Kleinberg's Operation With the patient in the prone position, a vertical incision is made over the affected area, and the spines and laminae of the vertebrae exposed. The various articulations between the adjacent vertebrae are scarified, and small pieces of bone elevated from the laminae and laid across the interlaminar spaces. The spines of the two upper and the two lower vertebrae are split as in the Albee operation. A graft may now be cut from the tibia. Transverse cuts, at intervals of about $\frac{1}{4}$ inch are made into the graft to aid its subsequent vascularization, and to add to its flexibility and so enable it to be more readily bent and adapted to the curve of the spine. The graft is placed in contact with the laminae and transverse processes on the concave side of the curve and its ends embedded between the split segments of the upper and lower spines. The intervening spines are each split into three or more segments which are spread out laterally. Some are turned down over the graft and some over the convex side of the curve. The periosteum and muscles are then restored by catgut sutures, and the fascia and skin approximated in separate layers.

The patient remains in bed for a week after operation without apparatus. Thereafter he is replaced on the frame and further traction applied, with the object of maintaining the position of maximum correction while healing is taking place. By the end of six months ossification should be complete and the vertebrae securely ankylosed, and the patient should be able to stand and yet maintain the correction of the back. Nevertheless a light plaster of Paris jacket is applied and the back supported for at least another six months, after which if there is no relapse the patient is given a corset. This is at first worn day and night, but gradually it is left off at night, then for a few

hours during the day, and finally altogether. During this period of treatment gymnastic exercises are unnecessary.

Removal of a Hemivertebra. Removal of the body and the posterior arch of a hemivertebra is feasible in the lumbar region, and appears to be the only means of correcting a lateral curvature caused by this anomaly. This resection is carried out through a lateral lumbar incision with a retro peritoneal approach. The posterior arch is removed sub periosteally through a dorsal mid line incision, and a spine fusion operation thereafter carried out. Such a removal is impracticable in the thoracic region.

Fascial Transplants for Paralytic Scoliosis.—Lowman devised a method of strengthening the abdominal wall in paralytic scoliosis. He introduces fascial strip transplants either subcutaneously or into the rectus sheath. These strips are embedded in a radiating direction from the umbilicus and fastened to the costal border or to the bony pelvis, or between these points. Lowman states that in all 12 cases thus treated the results were encouraging.

Summary of Treatment. The preferred treatment is exercise for the mild cases and continuous traction on a Bradford frame or a flat bed for the more severe cases and for pre operative cases.

The many mechanical methods of correcting the deformity which have been used from time to time suggest that no method is entirely satisfactory. The results from the use of the turnbuckle jacket show the most promise at the present time and this is the method which finds most favour prior to fusion operations.

It is of interest to record here the findings of the Research Committee of the American Orthopaedic Association who reviewed the end results of treatment in 425 cases of idiopathic scoliosis in 1941.

1. Practically none of the patients with scoliosis are cured, if correction of lateral deviation is a criterion.

2. In approximately 60 per cent of those treated by exercises the deformity increased and in 40 per cent it remained unchanged.

3. Correction without fusion resulted in complete loss of correction after support was discontinued, in the majority of instances.

4. Correction by the turnbuckle jacket and subsequent fusion has yielded better results in this series than have other types of treatment.

Antero-Posterior Curvature of the Spine

(including Adolescent Round Back, Senile Kyphosis, Spondylitis Deformans)

The foetal vertebral column possesses two *primary curves*, both convex dorsally. The upper of these extends from the head to the pelvis, the lower affects the sacral region.

After birth two *secondary curves* develop. As soon as the child begins to hold the head erect a *cervical curve* appears, its concavity directed backwards, and on the assumption of the erect attitude a lumbar curve appears which is also concave backwards. The object

of these secondary curves is to bring the centre of gravity directly above the stance of the body

The primary curvatures are dependent on the shape of the vertebral bodies, the secondary curves, on the other hand, are the result of the special shapes of the intervertebral discs, which are wider in front than posteriorly in the cervical and lumbar regions. It is interesting to note that if the intervertebral discs are removed, the spine tends to resume its foetal or infantile form—an effect commonly seen in “senile round back.”

In addition to the shapes of the bodies and of the intervertebral discs, normal spinal curvature depends to some extent on the long spinal muscles and on the ligaments binding the individual bony segments together.

Alterations in the normal antero posterior curvatures of the spinal column are frequently met with in the young and the old, and many erroneous ideas as to their mechanism and cause have sprung up. In general it may be said that deformed antero posterior posture of the spine must follow interference in one of the factors producing the normal curves, viz

1 *The bones*—this form is seen in tuberculosis, rickets, Kummel's disease, etc

2 *The discs*

3 *The long spinal muscles*—the type commonly seen in debilitated children with flabby muscles

The forms due to interference with the disc have been placed on an orderly basis, and for their proper understanding some knowledge of the anatomy and pathology of the discs is necessary

A Consideration of the Anatomy.

Schmorl's observations are based on the routine examination of about 7,000 complete spines, removed at post mortem examinations. As a result of a close study of them, he has been able to demonstrate many new facts pertaining to the anatomy and function of the component parts of the spinal column. Each spinal segment consists of a vertebral body, its neural arch, and an intervertebral disc. The intervertebral disc is an important component, and its features and functions will first be briefly reviewed.

The Intervertebral Disc. The disc is no longer regarded as a simple structure, but as a structure of three parts

(a) *A central portion*—the nucleus pulposus—which is more evident in young individuals, but is apparent throughout life. When the spine is cut in sagittal section the nucleus is found to bulge medially from its bed, indicating that it is contained in its central position under considerable tension. The disc is firm, elastic, and of fluid consistence. In virtue of a considerable fluid content it possesses a high degree of turgor, so that it swells or bulges out whenever the pressure of surrounding structures is removed. Developmentally it represents the

remains of the notochord. The nucleus acts as a cushion which serves to absorb and to distribute evenly pressure applied on the long axis of the column.

(b) *A peripheral portion*—the annulus fibrosus or annulus lamellosus—surrounding the nucleus. The annulus consists of a complex series of fibrous lamellæ, in structure it is coarser and less cellular than the nucleus, and it lacks the elasticity or inherent turgor of the central part of the disc. Many of the fibres are arranged concentrically around the nucleus forming a kind of fibrous capsule for it. In



FIG. 310 Round Back

addition, the fibres of the annulus establish certain other definite attachments. Thus some of them pass outwards from the disc, and, turning over the respective edges of the vertebral body, sink into the substance of the vertebra to form a species of Sharpey's fibres. Others pass out anteriorly and posteriorly to blend with the anterior and posterior longitudinal ligaments. Both these ligaments and especially the anterior are closely attached to the surface of the vertebral bodies by penetrating fibres which pass deeply into the substance of the bone as Sharpey's fibres. The complicated annular fibres serve to fix the disc, and to control the strains of torsion and tension to which the spine is subject.

(c) *The cartilage plates* two thin layers of hyaline cartilage interposed between the disc and the body of the vertebra. They are present only over the central part of the disc, and their function is to withstand the pressure of the nucleus and to maintain its form and shape. The cartilage plates are of great interest in two connections. In the first place they are set directly on the spongy cancellous tissue of the end surfaces of the vertebral bodies there being no intervening layer of compact bone as in the long bones. This is of importance in providing the means whereby the avascular intervertebral disc gains nourishment the required substances passing directly from the spongy tissue to the disc by a process of diffusion. In the second place the fibres of the annulus originate in the matrix of the cartilage, so that the whole disc is compactly and firmly bound together into a single unit.

The Vertebral Body Attention has already been called to the fact that the vertebral body lacks end plates of compact bone. The major portion of the surface is finely porous since the cancellous tissue is uncovered. Round the periphery, however, there is a raised ring

of compact bone—the so-called epiphyseal ring—and a good deal of interest attaches to it.

The upper and lower surfaces of a macerated developing vertebral body are not flattened as are those of the adult bone. Instead, there is a series of radially situated furrows, which pass right over the outer edge and extend for some distance on the outer surface, giving a cog-wheel appearance to the body. Further, the dried body is seen to be larger in its vertical extent posteriorly, so that it is roughly wedge-shaped with the apex of the wedge situated anteriorly.

In life, the upper and lower surfaces of the vertebral body are covered by a cap of cartilage; the vertebral surface of this cartilage is radially fluted, each fluting fitting into one of the radial furrows on the vertebral end surface. At about the age of 8 ossification commences in the peripheral part of the cartilage plate, which is now known as the epiphysis, and a small centre of ossification develops in the peripheral extremity of each of the cartilaginous flutings. Ultimately the various centres fuse to form a complete bony ring, and by the age of 25 this bony ring has usually fused with the vertebral body. The central part of the cap remains as the cartilage plate of the disc, and the fibres of the annulus arising from it gain firm attachment to the bony ring. It is obvious, therefore, that disturbance of the disc may exert a profound effect on the growth and normal development of the epiphysis.

Interest has also centred round the question of whether the growth in length of the vertebral column is due to the epiphyseal ring. Scheuermann believed this to be the case, and that the appearances which he named vertebral epiphysitis were due to interference with this. Schmorl has shown, however, that growth in length of the spinal column is produced by the cartilage plate, whereas the epiphysis is merely a fixation organ.

The Importance of the Intervertebral Discs.

From the foregoing it will be seen that the importance of the discs is not merely academic. Schmorl has clearly established the fact that they have a profound significance in spinal disease, and indeed the realization of their importance has provided us with a new conception of spinal pathology. The German workers have shown that the discs are liable to many abnormalities, and while a full consideration of these is beyond the scope of this work certain features may be noted.

The spine is unique in function and in structure; as Beadle says, it, more than any other part of the skeleton, is exposed to the daily wear and tear of functional activity, and this functional trauma, never in abeyance, can continue to work the most far-reaching damage to its structure.

The main incidence of such trauma is undoubtedly borne by the intervertebral discs, which thus reflect, like the arterial walls, the age and tone of the body tissues. With increasing age the nuclei pulposi lose their elasticity and fluidity, and the annular fibres their defini-

tion These changes are very marked in those whose occupations involve strong bodily work, but they may be observed to a greater or less extent in all ageing spines While changes in the fibrous portion of the disc are undoubtedly important any alteration in the cartilaginous plates is fraught with even greater significance since these plates are responsible for the maintenance of the integrity of the discs If they are intact the disc may perform its work with a fair degree of efficiency even though its substance has undergone considerable degeneration

The Pathology of the Discs

1 Developmental and Degenerative Changes The common changes in the cartilage range from localized bulgings towards the spongy tissue of the vertebral body to complete collapse and rupture In old spines such changes are the result of senile degeneration of the cartilage itself or of the deprivation of support that follows senile osteoporotic processes in the body of the vertebra The generalized collapse is seen in the increased biconvexity assumed by the disc at the expense of the bone and the stretching of the cartilage accelerates the degenerative processes It is probable that some slight shock is the cause of the final rupture or fracture

Schmorl has drawn attention to the frequency of congenital errors in the intervertebral discs These are of great importance in predisposing to pathological errors in the young Perhaps the commonest of these developmental anomalies is the presence of localized herniations in the nuclear regions of the discs—the so called *nuclear expansions* They occur mostly in the lower thoracic and lumbar regions and consist of small hemispherical protrusions of disc tissue into the substance of the vertebral spongy tissue The cartilage over these expansions is very much weaker and thinner and represents an area of diminished resistance where even the slight trauma of incessant functional activity is likely to lead to rupture or fracture of the cartilage

2 Fracture of the Cartilage Plates Prolapse of the Disc Apart from the developmental and degenerative changes described above Schmorl has shown that the cartilaginous plate is extraordinarily resistant to severe trauma and to those diseases which affect the vertebral body

The predisposing causes of rupture are

- (1) Nuclear expansion of the disc—a developmental error
- (2) Senile degeneration of the cartilage
- (3) Loss of support to the cartilage through osteoporosis of the vertebral body

The result of rupture is the *prolapse* or *protrusion* of the disc tissue into the spongiosa—a phenomenon the recognition of which we owe to Schmorl and the Dresden school of spinal pathologists The frequency of the condition may be gauged from the fact that these observers found it in 30 per cent of all spines examined and in all cases of juvenile and senile antero posterior spinal curvatures

The presence of the disc tissue in the spongy bone of the vertebral body calls forth a series of reactive changes which are designed to resist the process. In youth the reaction is by the proliferation of cartilage and bone which leads to the limitation of the prolapse. In the aged the healing process is a different one, with granulations from the spongy tissue invading the disc and converting it into a shrivelled up nodule of fibrous tissue.

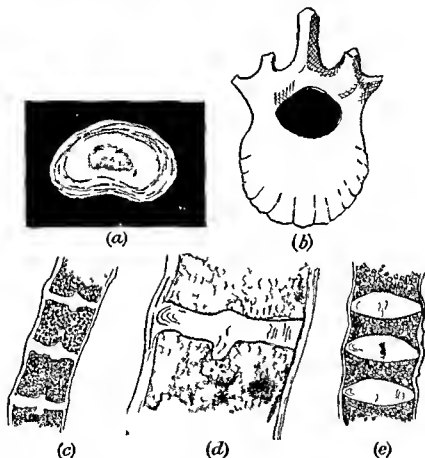


FIG. 311

- (a) Section of an intervertebral disc showing the central nucleus and the laminated annulus.
 (b) Surface of a vertebra showing clearly the furrow formation.
 (c) Section of a spine showing series of nuclear expansions.
 (d) Typical nuclear prolapse. The branching nodule consists of cartilage.
 (e) Osteoporosis of the vertebral bodies. The inherent rigidity of the discs has caused a certain amount of collapse making the vertebrae not making the normal fall.

In youth, the loss of disc substance into the prolapse interferes with the function of the discs while the alterations in shape and size give rise to important spinal deformities. In older individuals where healing is by granulation the destruction of disc tissue hinders the normal reaction to the changing demands of functional activity. In both, the mechanical shocks transmitted from segment to segment of the spine during arduous work are no longer absorbed or distributed evenly.

over the surface of the vertebral bodies, for they now impinge on the almost bare and unprotected bone. In this way serious changes arise and permanent deformity becomes established.

Kyphosis in Adolescence

(Juvenile Round Back Round Shoulders)

Kyphosis in adolescence may be due to

A Muscular (or postural) causes

B Bony deformity

C Disc lesions—the type often called ‘Adolescent kyphosis,’ or vertebral epiphysitis

(a) The Muscular Type

The physiological antero posterior curvature of the spine is subject to so many variations, even under normal conditions, that it is difficult to say when the border line has been crossed. Lovett recognizes four clinical types of error

(1) *Round Back* Here the spine has resumed its infantile form, the whole column presents a gradual thoracic kyphotic curvature, and the cervical and lumbar lordoses are absent

(2) *Hollow Round Back* The thoracic kyphosis is increased and there is a compensatory increase in the lumbar lordosis

(3) *Upper Round Back* There is an aggravation of the curvature in the upper part of the thoracic region, and the head and neck are thrust forward

(4) *The Flat Back* The spine is unusually straight and the thoracic and lumbar curves absent, but the shoulders are carried in a forward position

TREATMENT

The Flexible Case When the deformity can be reduced, either actively or passively, treatment should take the form of mild stretching and of supervised exercises designed to develop the spinal and abdominal muscles

The Resistant Case In this type the vertebral column must be thoroughly mobilized by stretching which is best done by stretching the shoulders over a padded roll. When the scapulæ are thus forced back they tend to stretch the contracted soft tissues, in particular the pectoral muscles

If the spine can by this means be rendered flexible, further treatment by developmental exercises should be carried out. A certain number of patients will require a corset or brace until their muscles have developed sufficiently to maintain the improvement secured by the exercises

(b) The Osseous Type

This occurs as a secondary deformity to disease or accident affecting the body of the vertebra, and is associated with appropriate symptoms, e.g. tuberculosis, rickets, Kummel's disease. It must be care

fully excluded from the other types when estimating the cause of the kyphosis

Under this heading must be included the somewhat rare condition of obscure origin termed vertebral osteochondritis or Calve's disease which however occurs earlier and is seen most commonly between the ages of 5 and 10. It is characterized by pain, fatigue and localized kyphosis in the lumbo dorsal region. A lateral X ray demonstrates the disease to be confined to a single vertebral body which is flattened, wedge shaped and shows a marked increase of density. In contrast to tuberculosis the adjacent inter vertebral discs are unaffected.

TREATMENT

The patient is placed on a hyperextension frame or a firm bed fitted with fracture boards for a period of from 3 to 6 months. Thereafter a light plaster or celluloid jacket is necessary for a short period during which the patient practises spinal exercises.

(c) True Adolescent Kyphosis (Scheuermann's disease Vertebral Epiphysitis)

This condition occurs in boys between the ages of 12 and 17 and gives rise to a marked kyphosis which is usually painless and which affects a segment of 1 or 5 vertebrae in the thoracic spine.

CLINICAL FEATURES

The area affected shows marked rigidity. The neck is usually flexed, the shoulders appear to droop, the chest is narrow and flat and the scapula prominent. It is usually possible to improve the deformity only in the very earliest stages of the disease.

RADIOLOGICAL APPEARANCES

These are characteristic. Edelstein points out that the disease shows three characteristic radiological stages, viz

(1) *Florid stage*—in which the vertebral body appears wedged with its apex to the front. There is some mottling of the upper and lower ring epiphyses, and the upper and lower surfaces of the vertebral body appear fuzzy and uneven. The intervertebral space is diminished.

(2) *Destructive stage*—in which the epiphyses now appear fragmented, and there is often disappearance of the upper and lower outer corners of the body.

(3) *Reparative stage*—in which density returns to the epiphyses, and definition to the upper and lower aspects of the body. The body, however, still retains its wedged appearance, which is permanent.

In many cases there are also obvious *nuclear prolapses* affecting a series of vertebral bodies.

ETIOLOGY

The disease is generally regarded as a sequel to disproportion between the *capacity* of the spine and the *load* it has to bear, but

there is no clear agreement as to the factors bringing about this disproportion. The various theories may be conveniently considered thus.

(a) Factors diminishing the Capacity of the Spine

(1) *Circulatory disturbance* Axhausen suggested that the condition was akin to Perthes disease and was due to diminution in the blood supply to the epiphyses.

(2) *Infection* has been suggested as the main factor. The lack of pain disproves this theory.

(3) *Endocrin dysfunction*

(4) *Metabolic or chemical causes* acting on the growing epiphyses.

(5) *Congenital disc prolapse*. It is supposed that the vertebral bodies are brought nearer together as a result of the prolapse and with the posterior articulation acting as a hinge rotary movement occurs so that the anterior edges of the body are swung closer together than the remainder. The water cistern effect is lost, and pressure disturbance arises on the anterior part of the body, sufficient to interfere with the proper development of the epiphysis and to cause wedging of the body.

(b) Factors causing increase in the Spinal Load

(1) Increase in the body weight.

(2) Multiple minor traumata.

(3) Shortening of the hamstring tendons. Lambriudi has shown that when the hamstrings are shortened the effect is to cause increased flexion at the thoracolumbar junction on stooping. As a result of this aided by minor trauma (e.g. leapfrog and gymnastic exercises) hæmorrhage occurs beneath the cartilage plates. The cartilage is apt to fissure or crack and the disc tissue to prolapse.

Schmorl attributes the condition of adolescent kyphosis to a primary disturbance of the discs while Lambriudi attributes it to trauma and secondary lesions of the discs. The truth probably lies somewhere between and it is probable that adolescent kyphosis is due to either congenital nuclear hernia or secondary nuclear hernia following trauma.

DIFFERENTIAL DIAGNOSIS

The condition has to be distinguished from tuberculosis which is also associated with a kyphotic deformity. The absence of pain and spinal rigidity and the nature of the radiological appearance render this easy.

TREATMENT

In this form of kyphosis the spinal error is progressive if allowed to go untreated but if the patient comes under treatment during the early phases there is some hope that the condition may be arrested. Treatment should be on similar lines to that of early tuberculosis of the spine viz. absolute recumbency on a Whitman frame with traction applied to the head or legs or both, for a period of 3 to 6 months.

Towards the end of this period hyperextension and general spinal exercises are instituted and weight bearing gradually resumed. If, in spite of exercises, the tendency to deformity persists, a light plaster jacket of the same type as that used for recent spinal fractures is applied in the optimum position obtainable and exercises continued in the jacket. This jacket is retained for about 6 months.

In the absence of symptoms and with the history that the deformity has remained unaltered for some considerable time, the opportunity of reduction has passed. In these circumstances treatment is confined to the improvement of posture and muscular development by means of gymnastic exercises.

KYPHOSIS IN ADULTS AND THE AGED

Increasing spinal deformity commonly accompanies advancing years and is associated with a variety of pathological changes in the spinal components. Many of these cases have hitherto been classed as osteoarthritic, and certainly the vertebral changes often bear a close resemblance to the manifestations of this disease in larger joints, such as the hip or the knee. Other cases have been ascribed to occupation, the demands of which have led to certain adaptive changes which are rendered permanent as the years go on. Unfortunately the whole problem has rested on a rather obscure basis, indeed, the bowed back of old age has been regarded as almost physiological and few attempts have been made to separate or classify the varying pathological types. When such a group of cases is analysed critically, it appears that several distinct types may be distinguished. These may be grouped as follows:

(a) Spondylitis ankylopoetica

(b) Spondylosis osteo arthritica

They may be considered briefly in turn.

(a) Spondylitis Ankylopoetica—Marie-Strumpell's Disease

This condition which is characterized by the deposition of bone in the ligaments of the spine is encountered with increasing frequency. It affects males between the ages of 20 and 35. The exact etiology is unknown but it is frequently associated with the presence of active toxic foci in the teeth, tonsils or elsewhere and not infrequently a gonococcal lesion has been demonstrated.

CLINICAL FEATURES

It is rarely seen at an early stage because early symptoms of muscle and joint pains are not of such severity as to warrant investigation. By the time an orthopaedic opinion is sought the patient's general condition has deteriorated and he has lost weight, he has a worried expression and complains of pain in the back of some considerable duration and of increasing stiffness and deformity of the spine. The pain is usually situated in the lumbar region and may radiate to the

thighs. Chest expansion is markedly diminished and not infrequently the hip joints are already affected and a flexion deformity exists.

MORBID ANATOMY

The earliest changes—usually in the sacro-iliac joints—are of osteoporosis. Later sclerosis and ankylosis of the sacro-iliac joints takes place and ossification appears in the ligaments of the spine until eventually the whole spine may be fused into a solid bony column. As the disease progresses the costovertebral joints are affected so that the chest wall becomes fixed and only abdominal respiration is possible.

The hip joints are frequently affected but peripheral extension to other joints is less commonly seen.

ETIOLOGY

It is supposed that the disease is the result of a toxic inflammatory reaction affecting the capsular ligaments of the larger joints and of the spine, which by producing hyperæmia, leads to decalcification. As the acute phase subsides, the callus made available locally is redeposited on the ligaments. The condition has also, therefore, been called "Infective Vertebral Osteosis."

TREATMENT

It is the aim of treatment to eradicate any obvious toxic focus, seeking especially any chronic gonococcal lesion, to control the pain and check the progress of the disease by means of deep X-ray therapy, securing at the same time the optimum position for ankylosis.

by gradual reduction of the deformity over a period which may extend to three months. The results obtained recently from deep X-ray therapy have been most encouraging, not only from the viewpoint of interrupting the otherwise almost inevitable progress of the disease, but from control of pain and increase of chest expansion and joint movement.

If deformity is present the patient is placed in a bed fitted with fracture boards following his course of radiation therapy. His natural inclination is to lie on his side, but he is encouraged to lie in the supine position for increasing periods each day until eventually he is able to recline with a pillow placed under the small of the back in an attempt to reconstitute the lumbar curve. As his posture improves extension of the cervical spine is obtained by fixing the patient's head to the

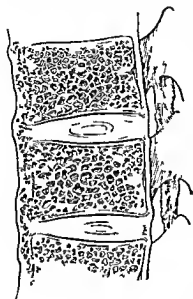


FIG. 312.—Spondylitis Ankylopoetica (Marie Strumpell Disease)

Diagram showing the ossification of the anterior longitudinal ligament.

raised end of the bed by means of a head halter and allowing the downward pull of his body weight to exert the necessary traction

Throughout the period of recumbency and correction of the deformity it is essential that he practise not only deep breathing exercises but exercises designed to maintain muscle tone and mobility of the joints especially of the hips and cervical spine

When the maximum correction has been obtained a light plaster jacket is applied in the optimum position. The jacket is retained for a period of about 1 year and thereafter a spinal brace of Goldthwaite type is fitted

If the patient is seen only when both hip joints are ankylosed division of one or both femoral necks will provide a pseudarthrosis which will allow the patient greater freedom of movement and the ability to sit in a chair

(b) Spondylosis Osteo arthritica

This includes several disease entities

1 True Senile Kyphosis

MORBID ANATOMY

The whole spine appears remarkably well preserved but the vertebral bodies are somewhat wedge shaped. In their major portion the discs appear relatively normal but there are constant changes at their anterior edges varying from patches of necrosis or fibrosis to total disappearance. In the latter event the adjacent vertebral bodies may be joined at their anterior edges by bands of spongy bone. The changes are most marked in the upper and middle thoracic regions.

THE EXPLANATION OF THE CHANGES

Schmorl has demonstrated beyond doubt that the earliest phenomenon is the necrosis of the anterior part of the disc. He suggests that it is a natural response to the greater degree of strain exerted on this area of the disc especially in those whose occupation is heavy and demands continual stooping. The necrosis leads to tears in the annulus and finally to the complete dissipation of the disc as a result of which the anterior ends of the two opposing bony surfaces are forced into contact. Long continued pressure of this kind leads to bone absorption and the body of the vertebra gradually assumes a wedge shape. If the anterior ends of the cartilage plates are at the same time destroyed the adjacent bodies may become ankylosed by bridges of new bone

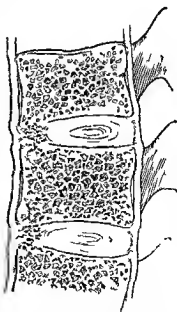


FIG. 313.—Senile Kyphosis

Diagram showing the bodies joined to their anterior edges by spongy bone

The significant features of the disease therefore are (1) kyphosis due to

- (a) Necrosis of the anterior parts of the disc
- (b) Bone absorption at anterior edges of the vertebral body
- (2) Relative health of the main mass of disc substance

2 Spondylosis Deformans

MORBID ANATOMY

The most typical feature of this form of disease is the generalized degeneration of the intervertebral discs. These degenerative changes may take the form of brown degeneration or necrosis. In many cases the disc is prolapsed and invaded by granulation tissue so that it is present only as an inert fibrous nodule.

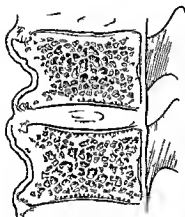


FIG. 314—Spondylosis Deformans

Diagram shows some flattening at the epiphyseal discs and osteophyte outgrowths in front of the bodies a little distance from the upper and lower edges.

The shape of the actual vertebral body is usually unchanged but the epiphyseal rings may be flattened out. Characteristically there are osteophytes of varying size on the anterior and lateral edges of the vertebral body. These lie a little below the outer edge of the epiphyseal ring and proliferate so as to overlap the intervertebral space until eventually osteophytes from adjacent vertebrae may fuse together. These osteophytes tend to be arranged in rows and adjacent nodules are usually connected by raised bony ridges on the antero-lateral surface of the body. It seems clear that this marginal bone proliferation is the result of abnormal tensions on the fibres of the anterior longitudinal ligament and the bony ridges actually reproduce with faithful accuracy the direction of the ligamentous strands.

The condition therefore has been called poly spondylitis marginalis.

As a whole the spine may or may not show a kyphotic deformity usually it does but the kyphosis must not be considered a part of the spondylitic process. Rather it is the result of a co-existing simple kyphosis.

THE SEQUENCE OF EVENTS

These changes have been carefully worked out by Schmorl and are well described by Beadle. Formerly this condition was referred to as osteoarthritis or as spondylitis deformans. Since the bulk of the changes affect the discs and the vertebral bodies where there are no joints in the true sense of the word the former term should be discarded. In the absence of evidence of an inflammatory process the term spondylitis should also be avoided and hence Schmorl has coined the term spondylosis.

The essential factor in the process is obviously the degeneration in the discs. As these waste there results an increased mobility of the vertebrae one on the other and the consequent continuous tugging on the fibres of the anterior longitudinal ligaments which are closely attached to the front and sides of the vertebrae, leads to the production of bony exostoses or osteophytes. The looser attachment of the posterior ligament prevents the gross changes seen anteriorly but occasionally small osteophytes are found on the posterior surface of the vertebral bodies as well.

The occasional absence of kyphotic deformity is due to the fact that the disc degeneration being diffuse and the posterior intervertebral articulations looser than in youth the bodies of the vertebrae sink together more or less squarely. Nevertheless kyphosis is a frequent accompaniment and is due to a greater or earlier degree of degeneration in the anterior edges of the discs together with the habitual assumption of postures which throw severe strains on the front parts of the vertebral bodies.

Von Bechterew's Disease The term Von Bechterew's disease is applied to a spondylosis deformans affecting the upper thoracic region but associated with root pain muscular wasting and some sensory disturbance. The bone changes are associated with degenerative changes in the spinal cord but the exact nature of the disease is unknown.

3 Senile Osteoporosis of the Spine

MORBID ANATOMY

In this form of senile spine an osteoporosis of marked degree is evenly distributed throughout the spine. The bone trabeculae are largely absorbed and replaced by marrow. The discs are usually in a state of excellent preservation and bulge markedly into the atrophied spongy tissue of the vertebral body. Viewed as a whole the spine is grossly deformed owing to the softened vertebral bodies being unable to withstand the superincumbent weight.

THE EXPLANATION OF THE PROCESS

It seems that this type of spinal deformity is common in those who through the light nature of their work or profession or through the inherent strength of their constitution escape the common stresses of advancing age namely degeneration of the discs or senile kyphosis. Schmorl believes the absorptive process is analogous to an atrophy of disuse.

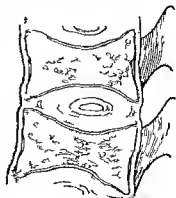


FIG. 310.—Senile Osteoporosis

Diagram showing the fish-tail and pores of the vertebra and the ligament of the disc.

Summary of Kyphosis in Adults and the Aged

The continual strain on the individual components of the spine inevitably leads to a series of degenerative changes as age advances. These vary according to certain inherent tendencies, and the nature of the individual's employment or exercise. Other things being equal, the changes fall naturally into three groups:

- 1 Degeneration in the interior parts of the discs, with kyphosis
- 2 Degeneration in the entire disc, with new bone formation, with or without kyphosis
- 3 Degeneration in the vertebral body, with marked deformity

The trend of modern opinion is to regard the spinal changes discussed above as the inevitable sequelæ of advancing years. In many cases the condition has little beyond a pathological interest, and treatment is impossible or useless. The main interest of Schmorl's work up to the present is, therefore, concerned with accurate diagnosis rather than treatment.

An accurate knowledge of the underlying pathology will lead to the elucidation of many previously obscure radiological appearances. Thus it is now known that increased biconvexity of the intervertebral discs is evidence of a senile osteoporotic change in the vertebral body, and the condition can be differentiated with certainty from spondylosis deformans which is associated with loss of the intervertebral space and the lavish production of marginal osteophytes. Prolapse of the disc reveals itself as an area of increased density in the substance of the vertebral body. In the senile kyphotic spine the radiological appearance is distinctive, the widespread curvature, the loss of the intervertebral space at the anterior aspect of the body, and the atrophic change at the antero-superior and antero-inferior angles of the body are characteristic.

CLINICAL FEATURES

The clinical features of Spondylosis Deformans, the so-called osteoarthritis of the spine, being a common condition of adult males must be considered in some detail. It occurs in the lumbar spine an area which is mobile and therefore most liable to the trauma of over exertion, and is thus seen most commonly in patients whose occupation, such as coal mining and dock labouring, have incurred strain over a period of many years.

It is frequently demonstrated radiologically that considerable arthritic change may be present in the lumbar spine and the patient remain symptomless. Some factor such as a recent minor injury, increase in weight or the presence of an active toxic focus is usually responsible for the onset of symptoms.

In the earliest phase the patient is conscious of his back and has difficulty in carrying out certain movements. There is frequently a history of attacks of "lumbago." At a later stage the pain never completely disappears, one attack merging into another. With each

successive attack the spinal symptoms become more marked and movements more limited. Pain is present particularly in the morning when he straightens up after bending. Thus he often notices that he has difficulty in putting on his boots. The pain and stiffness progress with remissions until eventually the whole spine is involved.

Sensory symptoms become prominent later and are due to pressure on the nerve roots as they leave the spinal foramina. They may occur before any radiological evidence of the disease is apparent. Motor root symptoms are uncommon.

When osteophytes are present the X-ray picture is characteristic. In the degenerative form the vertebrae are atrophied and the vertebral shadow uneven. In the more advanced cases a mottling or stippling of the vertebral shadow is evident.

The remaining forms of senile kyphosis are evidenced by a change in the figure. The individual loses in stature and carries himself with a pronounced stoop with the head and shoulders apparently thrust forward.

DIAGNOSIS

In addition to distinguishing between the different members of this series senile kyphosis must be distinguished from those diseases of the vertebral body which result in deformity. These are mainly tuberculosis—rare at this age—Paget's disease, Kummel's disease and secondary malignant deposits. The differential diagnosis presents no difficulties if full account is taken of the clinical history in conjunction with the radiological features.

TREATMENT

The treatment of spondylosis may be considered under two headings.

(1) *General*

- (a) The eradication of toxic foci in the teeth, tonsils, genito-urinary and gastro-intestinal tracts.
- (b) Correction of postural defects.
- (c) Reduction of weight.
- (d) The possibility of a change to a less arduous occupation should be considered.

(2) *Local*

The common physio-therapeutic measures of massage, radiant heat and diathermy are all of service in relieving pain and accompanying muscle spasm. When the acute phase has passed to these methods of producing local heat are added graduated exercises to maintain the maximum range of mobility.

In the absence of gross osteophytic formation or active toxic focus considerable relief of symptoms may result from gentle manipulation of the lumbar spine. In more advanced cases recumbency on a Whitman frame or firm bed may be necessary to reduce the deformity prior to the fitting of a spinal support.

The remaining conditions in this series are seldom amenable to

active treatment, but if pain is a prominent feature the use of a spinal brace will afford a considerable measure of relief

Spina Bifida

The term spina bifida is applied to a congenital gap in the vertebral column through which the contents of the spinal canal may

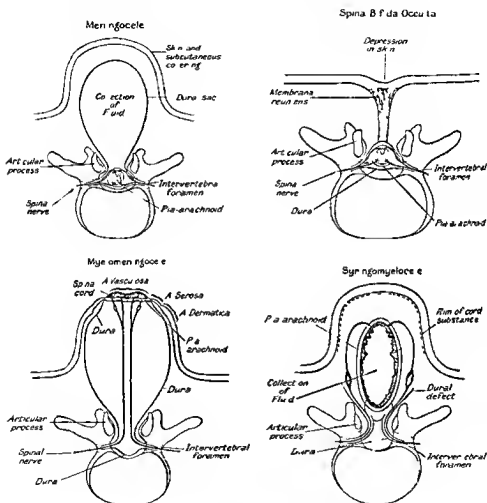


FIG. 316.—Diagrammatic representation of the anatomical relations of the various types of Spina Bifida (After Frazer)

be protruded. It is a distressing and a grave deformity, and is said to occur about once in every thousand births. Many of the patients do not survive birth and many others die in the early months of life. Fraser states that 80 per cent die in the first year of life.

MORBID ANATOMY

Five varieties of spina bifida are recognized

1 Meningocele Through a congenital defect in the posterior wall of the spinal column there is a sacular protrusion of the dura mater. This dural sac is attached to the parent membrane by a narrow neck. It contains cerebro spinal fluid but no nerve tissue.

2 The Myelo meningocele There is usually a large gap in the posterior wall of the spinal column through which protrudes a sac which is more often sessile than pedunculated. It contains both spinal fluid and nerve tissue the latter varying with the level of the defect. Von Recklinhausen recognizes three areas on the surface of the sac of a myelo meningocele.



FIG. 317—Spina Bifida Specimen showing the nerves leaving the spinal canal.

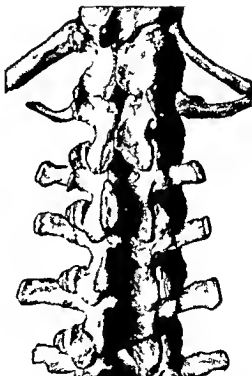


FIG. 318—Spina Bifida of the first and second lumbar vertebrae.

(a) The central area—the medulla vasculosa—which is recognized by an overlying area of granulation tissue.

(b) Surrounding it the zona epithelioserosa covered by a thin pellicle of serous membrane.

(c) The zona dermatosa—a covering of skin which is often thickened and hairy. The sac contains cerebro spinal fluid and nerve tissue the latter being attached to the medulla vasculosa of the sac.

3 The Syringo myelocele In this type the spinal cord itself forms the actual lining of the sac and is thinned out into a cyst by

distension of its central canal. The skin covering the sac is well formed and uniform but is often pigmented and covered with a thick growth of hair.

4 Myelocoele This deformity occurs most commonly in the lumbar region where normal closure is longest delayed. The defect appears as an elongated fissure with edges scarred and irregular and covered with telangiectases or surrounded by hair. Cerebro spinal fluid escapes from the sinus which is in direct communication with the central canal of the spinal cord. The condition is rarely compatible with life and is never amenable to surgical treatment.

5 Spina Bifida Occulta Here the development of the canal has gone on to a further degree and is fairly complete, but a defect exists in the vertebral laminae. Though there is no actual hernial protrusion of the dura the membrane is often connected to the skin by a fibrous band which passes through the bony hiatus and is known as the *membrana reuniens*. Tumours such as lipomata or angiomata



FIG. 319.—Lumbar Spina Bifida of the Myelomeningocele Type.
The right leg shows the talipes deformity which so often accompanies the spinal error.

are sometimes present either outside or inside the vertebral canal. The skin overlying a spina bifida occulta shows in many cases a localized overgrowth of hair. The *membrana reuniens*, according to Fraser, does not increase in size in proportion to the growth of the spinal cord so that sometimes about the tenth or twelfth year, it may prove to be too short and so lead to compression of the cord by traction. Various paralyses may then result.

THE CLINICAL PICTURE

The clinical features may be discussed in three groups:

- 1 The tumour
- 2 The nervous symptoms
- 3 The associated deformity

1 The Tumour The tumour is situated in the mid line and is most frequently found in the lumbar or lumbosacral region. It is of variable size and is increased by expiratory acts such as crying. It is

yielding and fluctuating and often transparent on trans illumination. The hiatus of the spinal column is demonstrable in the radiograph.

2 The Nervous Symptoms These vary with the degree of the spinal defect and may be absent in a meningocele or spina bifida occulta but very marked in the other varieties. The motor tracts suffer most severely and there may be complete paraplegia with muscular wasting and contractures. Sensory disturbances are usually extensive but limited to the lower limbs while trophic disturbances are common particularly perforating ulcers of the foot.

3 Associated Deformities In many cases of spina bifida other deformities are present affecting the spine itself or the lower limbs e.g. malformation of the vertebrae congenital dislocation of the hip.



FIG 320—Spina Bifida of the Occult Type



FIG 321—Spina Bifida of Cervical Vertebrae

contracted knees claw foot etc. Hydrocephalus is often associated with the condition.

DIAGNOSIS

The nature of the error is usually obvious but a spina bifida occulta may only be recognized by radioscopy. In the diagnosis of the type of spina bifida a radiograph taken after an injection of oxygen into the sac gives valuable help as it shows the distribution of any nerve structures within the sac.

TREATMENT

After birth the part should be carefully protected and the skin treated each day with spirit and antiseptic dusting powder.

The only kind of active treatment to be considered is operation and thus is carried out as soon after birth as possible. Leakage from the sac, ulceration of the surface, co existing paralysis of the limbs, a patulous anus, absence of the anal reflex or constant dribbling of urine, poor general health and the presence of hydrocephalus are all contra indications to operation.

The meningocele is the most suitable, the myelocoele quite unsuitable for operative interference. The aim is to excise the sac, to reduce or remove the contents and to repair the defect by a strong covering of skin and muscle.

The child is placed on an angled Whitman frame with the head down. This position is maintained throughout the operation and for at least 6 days afterwards. If the defect is in the lumbar region, rubber dam is glued above the buttocks to prevent contamination. A transverse elliptical incision is made to encircle the tumour, and the meningeal sac freed down to the gap in the spine. The sac is opened and the contents dealt with according to the type and distribution of the nerve structures. In a meningocele the sac is completely excised and the gap closed by sutures. In a myelomeningocele the vascular area contains nerve cells from which nerve roots may take origin, and it should therefore be carefully preserved. The termination of the cord and the nerve roots should be freed from the sac wall and returned to the vertebral canal. In a syringo myelocoele the whole cyst should be replaced after its size has been reduced by tapping.

The edges of the dura are carefully repaired by a continuous suture of fine silk or linen thread. The gap in the vertebral column is closed by musculo fascial flaps. Restoration of the bony canal lengthens the operation, increases the shock and is unnecessary.

In spina bifida occulta operation is indicated only if signs of cord compression develop in later childhood. The operation consists in the removal of the fibrous band which unites the dura to the skin, or of the extra dural lipoma if such exists. The track formerly occupied by the fibrous band is then carefully obliterated.

CHAPTER XIV

AFFECTIONS OF THE SHOULDER JOINT

Injuries in the region of the shoulder are common and the effects of trauma are demonstrable in all the components of the shoulder. The joint itself is frequently dislocated and fractures in this situation are numerous. These major injuries are usually described in general text-books and will not be discussed here.

The minor injuries however are of great importance. Damage to the soft tissues to the joint surfaces in the absence of dislocation and to the bony components in the absence of actual fracture have all to be considered. They assume increased importance from the fact that although apparently trivial they frequently lead especially in older persons to functional disability even after prolonged and painstaking treatment. Watkins from a consideration of the comparative anatomy of the joint suggests that the slow or incomplete return of function can be explained by its recently acquired capabilities. He points out that despite the gradual evolution of orthograde man there has been no development of new muscles. Those which were adapted to plantigrade action i.e. with the body held horizontally have merely had orthograde functions superimposed on them. Man's ability to raise and maintain his arm above his head is thus a late acquisition in the evolution of his muscular apparatus and is therefore correspondingly unstable. It follows that whenever the limb is disabled this most recent function is the first to be affected and the last to recover. Probably the most important of the movements of the shoulder at least in its relation to trauma is that of abduction and a clear conception of this is essential not only for appreciation of the effect of shoulder injuries but of the nerve lesions in this situation as well.

Abduction from the hanging position is begun by the contraction of the deltoid but to permit of this the head of the humerus must be held firmly against the glenoid by the contracting supraspinatus and its associated transverse muscles. During abduction of the arm by the deltoid the head of the humerus tends to slip upwards over the glenoid fossa. The supraspinatus pulling transversely holds the articular surfaces firmly together and in this way supplies a fulcrum against which the deltoid works. When the supraspinatus is paralysed or torn therefore abduction is considerably interfered with particularly in its initial stages. The deltoid carries the arm practically to the horizontal position and in this position the greater tuberosity

rests against the under surface of the acromion. Further abduction takes place mainly by the lateral rotation of the scapula on the chest wall, but in addition Martin has shown that there occurs a lateral rotation of the humerus at the glenohumeral joint. This serves to roll the greater tuberosity backwards out of contact with the acromion and permits the last few degrees of abduction to be carried out.

It is a noteworthy feature of shoulder injuries that even after trivial trauma abduction of the shoulder appears to be limited. In many cases it will be found that in point of fact pure abduction is not restricted but that loss of the all important external rotation may create this impression by abolishing the terminal part of the movement. Two important deductions may be drawn from this.

1 It is important in severe joint injuries necessitating immobilization to keep the arm laterally rotated.

2 In manipulating a stiff shoulder, it is important to restore the lateral rotation before full abduction is attempted.

A detailed description of the anatomy of the shoulder joint would be out of place here, but attention may be called to the wide range of movement in the joint, and the fact that the attachment of the arm to the body is effected principally by muscles. The importance of carefully applying the principles of muscle balance when treating injured shoulders is thus apparent. The location of the subdeltoid bursa, and the relationship of the circumflex nerve to the surgical neck of the humerus, in which situation it is peculiarly exposed to injury, should also be borne in mind.

Injury to the shoulder is constantly followed by pain, limitation of movement, and muscular atrophy. Pain in this region, however, may be produced by lesions elsewhere than in the shoulder itself. Various cervical, thoracic and abdominal lesions may be responsible and it is important to realize that such referred pain may in time lead to actual limitation of movement and stiffness of the joint. The capsule of the joint becomes relaxed from the disuse which follows the referred pain, and the mechanics of the joint are eventually so deranged that injury and inflammatory changes result. The pain is referred through the phrenic nerve and Cope has attempted to localize the causal lesions by mapping out the exact site of the referred shoulder pain. Thus pain in the clavicular area i.e. over the front of the shoulder, is referred from a lesion in the anterior part of the diaphragm. Pain over the supraspinatus muscle follows a lesion of the posterior part of the diaphragm. In lesions affecting the dome of the diaphragm the area of reference is over the acromio-clavicular joint. When both shoulders are painful the lesion is usually situated in the central tendon of the diaphragm.

In a recent study of 56 cases in which the chief complaint was shoulder pain, 14 were apparently produced by lesions without the shoulder. These cases included 2 of cervical rib, 3 of cervical arthritis, 1 axillary abscess, 3 of pleurisy, 1 of tuberculous pleurisy, and 4 with gastric disorders.

*A CONSIDERATION OF THE VARIOUS LESIONS***Sprain of the Shoulder Joint**

A sprain results when the shoulder joint is wrenched and the normal limits of its movement are exceeded. Owing to the shallowness of the glenoid cavity two abnormal movements may be produced at this joint namely forward and backward movement of the humeral head in the glenoid cavity. These displacements may be produced by falls on the back or front of the shoulder or upon the elbow or hand when directed backwards or forwards. The capsule the synovial membrane or the ligaments may be stretched or torn either alone or in combination. There is usually an extravasation of blood into the periarticular tissues and occasionally the effusion may involve the tendon sheaths so that sprains of the shoulder are likely to be followed by periarticular fibrosis or adhesions. The shoulder region is swollen and painful the pain being most intense when the patient attempts to move the joint in the direction which produced the injury. In nervous patients exaggerated symptoms may follow slight strains or even excessive use of muscles. In such cases extreme pain is felt not only over the shoulder but also down the arm so that neuritis is sometimes diagnosed. There is no tenderness over the nerve trunk however and sensory changes are absent.

In arriving at a diagnosis radiography should be employed to exclude bone damage. Sprains of the shoulder may be incidental to some other more serious injury such as a Colles's fracture and may pass unnoticed at the time.

TREATMENT

In the treatment of shoulder sprain the complication to be most feared is the formation of adhesions from prolonged immobilization. Accordingly from the earliest stage the shoulder should be moved both actively and passively after the application of some form of heat therapy. To ensure a good functional result the arm should be retained at an early stage in full abduction with a certain degree of lateral rotation by means of an abduction or platform splint. In later cases accompanied by marked limitation of movement it may be necessary to manipulate the joint under an anæsthetic and apply an abduction splint thereafter. Diathermy massage and the re-education of muscles constitute in all cases the subsequent treatment. The injection of 50-60 c.c. of normal saline under the acromion is often beneficial.

Muscular Strains in the Shoulder Region

The muscles in this region which are most commonly injured are the deltoid the biceps the medial rotators and more rarely the lateral rotators. Muscular lesions are distinguished by the fact that the muscle is painful when it is actively moved when resistance is offered to its

movement and when it is passively stretched. The pain is referred to the site of the strain and if any of the fibres have ruptured there may be acute pain on pressure at this particular spot. When a superficial muscle like the biceps has been completely torn through a prominence is visible at the site of rupture when the muscle contracts.

(a) *The Deltoid*. The deltoid abducts the arm only when the head of the humerus is fixed against the glenoid by the supraspinatus. Otherwise its first effect is to draw the head of the humerus upwards against the under surface of the acromion. Loss of abduction therefore must not be attributed to deltoid insufficiency until a complete investigation has been carried out. When the deltoid muscle is strained active abduction is either greatly restricted or painful. Passive abduction is easily carried out but if the patient is asked to hold the arm in the abducted position acute pain is felt and the arm falls limply to the side.

Gross rupture of the muscle is unusual. The more common lesion consists of rupture of a localized group of muscle fibres.

(b) *The Supraspinatus*. Injury of this muscle is so important and yet so rarely recognized that a special section is devoted to it (page 676).

(c) *The Biceps*. The main function of the biceps is to supinate the forearm and to flex the arm at the shoulder joint. Flexion of the elbow is a secondary effect.

Bicipital lesions not infrequently take the form of a complete division of one of the muscle bellies which is usually easily recognized. When the muscle actively contracts a tumour appears at the site of rupture and disappears when the muscle is relaxed. When the tendon is injured pain is experienced at the shoulder joint when the forearm is actively supinated, and there is tenderness over the tendon as it lies in the bicipital groove.

(d) *Rupture of the Long Head of the Biceps* is a rare but occasional lesion. According to Harris there have been 100 cases reported in the literature. In most cases there is a history of injury which may take the form of lifting heavy weights or violent extension of the forearm while flexion is being carried out, while in some cases the rupture appears to have been spontaneous during the performance of normal movements. The latter eventuality has been supposed due to gradual attrition of the muscle as a result of its constant playing over an irregularity of the bone in the region of the surgical neck, a sequel to a former fracture. Occasionally the tendon shows a degenerative change due to pre-existing arthritis or peri arthritis.

The clinical features are characteristic. The muscle belly shows a bulbous enlargement in its lateral half and is situated at a lower level than on the opposite side. There is often some discoloration in the region of the medial margin of the biceps at its upper part. Flexion and extension of the elbow produce pain.

Treatment should be by operation the results of this being satisfactory. The rupture is exposed by an antero-lateral incision over the

upper end of the biceps belly and the ends identified. The bicipital fascia covering the tendon in the bicipital groove may need to be divided if it has not already been ruptured along with the tendon. The suture is carried out with the elbow flexed. (See also description in Chapter XX.)

Recurrent dislocation of the long head of the biceps may follow tearing of the bicipital fascia.

(e) *The Medial Rotators* The muscles which produce medial rotation of the humerus are the pectoralis major and the subscapularis. The former is palpable in its whole extent and injury can be readily detected but the subscapularis attached as it is to the capsular ligament and to the lesser tuberosity is more deeply situated. In strain of these muscles pain is experienced during active medial rotation particularly if this movement be resisted. Inflammation of the bursa separating the anterior part of the shoulder capsule and the base of the coracoid process is also associated with pain on medial rotation.

(f) *The Lateral Rotators* The infraspinatus and the teres minor produce lateral rotation. Strain of these muscles is uncommon. It may result indirectly from traction on the muscles or from direct injury.

Acute Synovitis of the Shoulder Joint

Synovitis is less common in the shoulder than in the knee but when present it is painful and difficult to treat. It may be caused by injury or may be due to a local infection as in so called rheumatism and it is found in association with inflammatory conditions of the neighbouring bursæ or tendons. In the early stages of tuberculosis and arthritis deformans there is also a certain degree of synovitis.

The joint is swollen and movements are painful particularly when the arm is allowed to hang supported only by muscles and capsule. The synovial effusion is most obvious in the deltopectoral groove where the joint may be aspirated should the diagnosis be in doubt. Diagnostic aspiration may also be performed between the acromion and the head of the humerus inserting the needle horizontally and then downwards and backwards. An effusion into the subacromial bursa is best evacuated from the lateral aspect the needle being inserted just below the middle of the posterior edge of the acromion.

Synovitis of the shoulder is treated in a position of abduction on the lines laid down in Chapter VII.

Arthritis

Arthritis of the shoulder presents the same features as arthritis elsewhere and as it often co-exists with other manifestations of the disease the function of the other joints should be investigated in every case. There is some restriction of all the normal movements rotation being first affected followed by abduction the limitation of which may be masked by deflection of the body or by scapular action. Pain apart

from pain on movement is usually slight in the early stages but tenderness can be elicited by palpation over the front of the joint. In the later stages pain is often referred to the insertion of the deltoid.

Arthritis may exist for many months without producing any radiological evidence of its presence and it is probable that the relatively late occurrence of radiological change is the result of the non weight bearing function of the joint. In the early stages the only abnormality visible may be an increased density of the soft parts but eventually the typical Λ ray picture of arthritis is obtained.



FIG. 3.2—Osteoarthritis of the Acromioclavicular Joint

In arthritis following trauma the pain usually continues for about two months and during this period the joint should be adequately immobilized in the abducted position. When the pain has become limited as it usually does to the insertion of the deltoid a strip of adhesive plaster may be placed round the upper end of the humerus and the patient allowed to move his arm. Movement slowly increases under the influence of massage and gentle passive motion but if resistant manipulation under an anæsthetic may be attempted to break down the peri articular adhesions. This is done only in the late stages, and the greatest care should be taken lest a spiral fracture of the humerus be produced. In the case of the right shoulder the manipulator's left hand supports the scapula and acromial region the right hand grasps the upper third of the humerus, while the patient's arm

lies along the surgeon's forearm. Leverage can thus be exercised through the elbow of the patient with little danger, as the upper end of the humerus is protected. The joint should be moved once in each direction. As in arthritis elsewhere, a careful search should be made for infective foci which, if found, should receive treatment.

Bursitis

(a) **Sub-Deltoid, or Sub-Acromial, Bursitis** The sub-acromial bursa lies under the upper part of the deltoid muscle, and extends upwards underneath the acromion process. It separates the greater tuberosity of the humerus from the deltoid muscle and the acromion process. Although frequently diagnosed, it is doubtful whether primary affection of this bursa is as common as it is supposed to be, for any inflammatory process involving the joint will in time implicate the bursa. Since abduction is the position of choice in treating shoulder lesions generally, as well as sub-deltoid bursitis specifically, any improvement in shoulder symptoms following such treatment cannot be accepted as incontrovertible evidence of the bursal affection alone. Indeed, most authorities believe that the bursa is infected only secondarily to the joint structures and never alone. There are cases, however, where loose bodies can be felt, or can be shown by X-ray examination, in these cases there is a localized swelling and pain confined to the region of the bursa on abduction of the shoulder joint. Tenderness can be elicited just below the acromion process to the lateral side of the intertubercular sulcus, but this ceases when the arm is abducted, as the bursa then disappears under the acromion and cannot be palpated.

(b) **Sub-Coracoid Bursitis** The sub-coracoid bursa is situated between the tip of the coracoid process and the capsule of the shoulder joint, it extends up to and even over the lesser tuberosity of the humerus. Normally the humerus and the coracoid are closely applied to each other, the tip of the latter resting against, or being opposite the lesser tuberosity of the humerus. This contact is much closer when the shoulder is allowed to droop, the humerus being in consequence moved forwards, medially and downwards. It follows that though this bursa is not particularly exposed to external violence, it is yet distinctly liable to suffer derangement through irritation from the pressure of the lesser tuberosity against the coracoid when the arm is used a great deal. It is not surprising, therefore, to find that persons with round shoulders frequently suffer from shoulder pain. The cases which were ascribed by Thomas to a tight axillary capsule and which were cured by stretching were probably examples of sub-coracoid bursitis.

The patient complains of pain in the region of the coracoid, and there is definite tenderness over the interval between the two bones. Late cases, in which adhesions are present, have marked limitation of lateral rotation and abduction. In recent cases relief is obtained when

the arm is laterally rotated and there is a corresponding increase of pain when the humerus is pressed towards the coracoid

Peri arthritis

This is a distinct entity with a more or less constant clinical syndrome. The symptoms arise spontaneously or after a trivial twist or strain in a shoulder the seat of a tendonitis of the supraspinatus tendon. The patient may attribute his condition to such a trauma as excessive work in the garden washing windows or playing golf. It is believed that foci of infection and glandular dysfunction are more important in the causation of the condition than trauma but their exact importance is difficult to determine. Whatever the general factors it seems there must be an additional local disturbance.

It usually occurs in males over 40 years of age and though the right shoulder is the more often implicated the condition is not infrequently bilateral. Pain is diffuse and tenderness is not confined to the tuberosity or region of the spinatus. It is not accompanied by effusion into the joint. The patient is unable to lie on the affected shoulder because of the pain. Movements of the shoulder are guarded by muscle spasm but there is no complete limitation as in tuberculous arthritis. Abduction and external rotation are limited while in other directions the movements are free. The limitation of movement by muscle spasm rapidly passes to limitation by adhesions—few in number at an early stage but eventually generalized and producing what is known as the frozen shoulder. The condition has to be distinguished from one in which movement is limited in every direction due to protective spasm from arthritis.

THE DIAGNOSIS OF SHOULDER DISABILITIES

The diagnosis of shoulder disabilities may present great difficulty, and accuracy may be obtained only after the expenditure of considerable time and care. It is important to eliminate preconceived impressions and it should be constantly borne in mind that severe disease processes no matter where they originate sooner or later involve all the related structures of the joint. While it is true that from the point of view of treatment—which does not materially differ in the various lesions—accurate diagnosis is not essential, nevertheless the amount, the nature and the order of treatment are certain to have speedier and more lasting effects if based on a correct conception of the pathology.

The patient's history should be carefully elicited and too much attention should not be paid to the occurrence of minor traumata as most persons can recall some previous injury to any affected portion of the body.

Every investigation of shoulder symptoms should conclude with a radiological examination of both shoulders in a position of lateral rotation. In this way lesions such as myositis ossificans, loose bodies and small fractures involving the articular surfaces will be revealed.

THE TREATMENT OF SHOULDER CONDITIONS

While the treatment will of necessity vary with the cause of the condition there are several principles which are applicable to almost all shoulder lesions. Most of them are improved by being placed in the optimum functional position—i.e. 75° abduction with a small amount of lateral rotation. It is important to insist on a very gradual return to activity and in the severer lesions supports should be maintained for four or six weeks.

Arthritis In addition to ordinary medical treatment it is important to prevent strain and to correct unnatural positions. The shoulder should be held back and square since this brings the joint surfaces together and helps to relieve the symptoms.

Atrophic arthritis is best treated by attending to the general condition by instituting colonic lavage and abdominal massage by correcting faulty body mechanics and by decreasing the carbohydrate of the diet. The eradication of focal sepsis will greatly increase the general body resistance. The usual physiotherapeutic and orthopaedic measures are applied to the joint.

Sub-Coracoid Bursitis The essential point in the treatment of this condition is the prevention of friction between the two bony points. These patients stand with their bodies relaxed and their shoulders drooping forward so that to begin with the patient should be made to lie in the recumbent position with a narrow pillow between the shoulders. Hot fomentations will diminish the inflammation and thereafter postural exercises may be started.

Sub acromial Bursitis Mild cases of bursitis respond to conservative treatment consisting of rest with the arm abducted on a splint. Diathermy and massage are helpful in alleviating the inflammation and preventing muscle atrophy respectively. In cases which do not respond to this form of treatment especially if an X ray picture shows any calcareous deposit operation is indicated.

A vertical incision is made downwards from the acromion process and the deltoid exposed lying under its fascia. After division of the latter the muscle is penetrated by blunt dissection and the bursa opened. Associated lime deposits in the supraspinatus tendon are curetted and removed. The walls of the bursa are removed as thoroughly as possible and the wound closed. The arm is put up in an abduction splint and conservative treatment continued.

Peri arthritis No manipulation or forcible passive exercise is permitted in the early stages but active exercises are practised under supervision. Massage, radiant heat and short wave therapy are helpful but much less important than active exercises which should be practised frequently throughout the day. These are best carried out in recumbency or in the stooping position.

LESIONS OF THE SUPRASPINATUS TENDON

The superior and the posterior portions of the capsule of the shoulder joint are strengthened by the incorporation of the flat expanded tendons of the supraspinatus the infraspinatus and the teres minor. These tendons form a thick continuous fibrous sheet fused with the underlying capsule of the shoulder joint and separated from the deltoid and the acromion process by the subdeltoid bursa.

The supraspinatus lies superiorly, and forms the roof of the joint as well as the floor of the sub acromial bursa. Complete rupture of its tendon occurs usually in close proximity to the greater tuberosity. The muscle then retracts, leaving a direct communication between the bursa and the joint. The gap between the edges varies from $\frac{1}{2}$ to $2\frac{1}{2}$ inches but is most commonly about $1\frac{1}{2}$ inches. There are, as a rule degenerative changes in the intact portion of the supraspinatus, and in the infraspinatus tendon.

In addition to such extensive ruptures it is probable that smaller tears may occur, involving only a few of the tendon fibres. These small tears may result in the deposit of calcified nodules in the tendon.

ETIOLOGY

With every abduction movement of the shoulder there is friction and contact of the supraspinatus tendon against the acromion process. The subdeltoid bursa from its position minimizes this friction. As age advances, however especially in hard working labourers the bursal protection becomes inadequate and degenerative changes occur from the constantly repeated trauma. The fibres become worn and a tendonitis occurs. As the tendon is avascular calcareous deposits may occur and produce calcification of the supraspinatus. When either of these conditions occurs it is not surprising that a partial or complete rupture may easily occur. A third sequel of the tendonitis is the onset of peri arthritis resulting from a simple strain plus probably some toxic focus.

(a) Tendonitis of the Supraspinatus Tendon

This symptom complex often follows a history of a minor sprain and the patient comes complaining of pain in the outer aspect of the shoulder and over the deltoid insertion. It does not radiate down the arm. There is tenderness over the greater tuberosity at the insertion of the supraspinatus tendon. Movements are usually not limited but there is an area in the arc of abduction between 60 and 120 degrees which is acutely painful, and apparently is at the point where the tender area impinges against the margin of the acromion. There is again sharp pain through the same arc from 120 to 60 on adduction from the abducted position. There is no abnormality on X ray.

Good results in such cases follow the injection of 10 c.c. of 2 per cent Novocaine into the painful area. The pain is relieved for two

hours but recurs usually for a period of four or five hours and then gradually dies away. It may be pretty acute when it comes on again and morphia may be necessary. If the symptoms are slow in disappearing after this injection short-wave therapy and radiant heat are of value in encouraging the necessary revascularization.

(b) Calcification of the Supraspinatus Tendon

The occurrence of calcareous deposits overlying the tip of the greater tuberosity of the shoulder has long been recognized. At first these were thought to be deposits in the sub acromial bursa, or thickening of the bursal wall, but Codman has pointed out that the deposits lie deep to the bursal floor, and actually embedded in the supraspinatus tendon.

The condition occurs in adults of all ages, and there is usually a history of injury, as for example in throwing a cricket ball. The condition may pursue an acute course, the trauma being followed by severe and constant pain, or the injury may be recovered from and be so mild that it causes nothing more than a transient pain and stiffness. Later the patient may develop gradually increasing stiffness, with pain on abduction to a right angle and a constant ache over the greater tuberosity.

The X ray appearances are characteristic. There is an uneven and irregular shadow over the greater tuberosity. This can be distinguished from a loose body in the joint, according to Elmslie, by the fact that it lies too far out to be intra articular. In addition to the shadow, the greater tuberosity shows a greater or less degree of rarefaction which may even amount to complete dissolution of its cancellous texture.

PATHOLOGY

Elmslie has studied the pathology of a series of cases carefully. He was unable to demonstrate a tear in the supraspinatus muscles or the presence of necrotic tissue. The material removed was composed of non crystalline calcareous matter embedded in a mass of inflammatory cells containing foreign body giant cells. In older cases well formed fibrous tissue was present. Cultures taken at the time of operation were sterile, and the biochemical examination of the contents showed the presence of amorphous calcium carbonate and phosphate. The material in the early stage is creamy in consistence, then like tooth paste, and only finally frankly calcareous.

In some cases the material from the greater tuberosity of the humerus is yellow in colour, and the calcareous matter is scattered throughout it as gritty particles. In these cases the tissue contains large cells with foamy cytoplasm resembling those seen in the skeletal lipid dystrophies.

The source of the calcareous deposits is the impairment of blood supply from preceding tendonitis. The deposit of lime produces a secondary hyperæmia which may cause absorption of the deposit and also cure the underlying tendonitis.

TREATMENT

In acute cases immobilization in an abduction splint for a period of two to three months is associated with disappearance of the deposit and the subsidence of the inflammatory process. At the same time massage and short wave therapy and radiant heat are of considerable benefit. Active exercises are encouraged as soon as possible. Any resulting stiffness of the shoulder may be cured by manipulation.

In chronic cases the quickest return of function follows operation. The mass is usually too thick to be removed by aspiration though this may be tried first. The tendon is exposed by an anterior incision and the deposit removed by a sharp spoon. The underlying tuberosity should be incised and the cheesy deposit contained in it evacuated, the walls of the resulting cavity being broken to facilitate the filling up of the dead space. There is immediate and quick relief from the pain and full active exercise can be practised at once.

(c) Incomplete Rupture of the Supraspinatus Tendon

An incomplete rupture of the tendon is a common sequel to tenosynovitis though often not diagnosed. It is said to occur in no less than 30 per cent. of all ciders.

Pain is complained of over the shoulder and this radiates down the circumflex nerve to the deltoid insertion. Tenderness is present over the insertion of the tendon. Abduction is usually possible though there is pain at a certain stage when the torn fibres impinge under the acromion. This is usually at 90 or 100 degrees. Abduction can easily be prevented by resistance. With a greater degree of tearing abduction may become impossible. Scapulo humeral abduction is reversed in that the scapula abducts on the chest wall before shoulder movement commences.

Immobilization in an abduction splint is tried in the early stages and continued for some six to eight weeks. If no improvement is produced the tendon is exposed by operation and the tear dealt with as in the complete rupture. If there is little evidence of a tear the subdeltoid bursa is fully explored and any hyperaemic fringes and the bursal wall removed. If nothing more than tendinitis is found the tendon is scarified to produce revascularization and this usually relieves the symptoms.

(d) Rupture of the Supraspinatus Tendon

The actual tear may be associated with only slight pain but there is immediate weakness of the arm and the patient is unable to abduct the shoulder. Occasionally a definite crack in the shoulder accompanies the pain at the moment of injury. Localized tenderness can be elicited over the tip of the greater tuberosity or just medial to it but it disappears when the arm is abducted since the tuberosity then passes beneath the acromion. Attempts at active movement may be accompanied by coarse crepitation in the region of the bursa and by a chir-

acteristic "abduction" syndrome. The supraspinatus initiates abduction by fixing the head of the humerus against the glenoid cavity. Thereafter the deltoid assumes control and completes the movement. After complete rupture, the patient cannot voluntarily perform the first fifteen degrees of abduction, but can complete the movement if the first stage is performed for him. When the tear is slight and incomplete full abduction may be possible, though the early phase is attended by considerable weakness. The initial attempts are painful, but the pain, like the tenderness, disappears when the tuberosity is carried beneath the acromion, only to reappear as the arm is brought down from the abducted position.

When the patient is inspected as he stands with his arms at the sides and elbows pulled backwards, the tuberosity of the humerus may appear unduly prominent on the injured side and a sulcus may be seen proximal to the tuberosity where the tendon should be. In the sulcus there is usually a tender spot which rotates with the humerus and disappears under the acromion when the humerus is abducted.

Diagnostic signs are produced as the arm descends from the upright position. Lowering to a right angle is painless, since it occurs between the scapula and the chest. The rest of the movement—at the shoulder joint proper—causes acute pain and, the shoulder muscles suddenly relaxing, the arm drops to the side, the patient wincing with pain.

Another sign is evident when both arms are elevated—a change in contour of the deltoid region on the affected side due to an alteration in the folds of the skin between the shoulder and the neck, caused by joint fluid being driven into the subdeltoid region owing to the tenuity of the lower portion of the capsule.

DIAGNOSIS

The diagnostic sign is a greater limitation of active than of passive abduction in the presence of a normally contracting deltoid. Abduction cannot be carried out by the deltoid alone, the supraspinatus is an essential synergist. If the supraspinatus is inactive strong contraction of the deltoid pushes the humeral head up towards the acromion and holds it there while the scapula rotates. Scapular movement accounts for some 50 degrees of abduction, but there is no true abduction at the shoulder joint. The deltoid can be felt strongly contracting thus excluding circumflex paralysis, and since passive movement is possible adhesions cannot be the cause. The wince of pain at 90 or 100 degrees abduction as the limb is raised or lowered passively, and the tenderness on pressure over the insertion of the supraspinatus clinch the diagnosis.

Codman describes certain conditions, symptoms and signs which indicate complete rupture of the supraspinatus tendon and which should be present within twenty-four hours after the accident—

- (1) Occupation—labour
- (2) Age—over 40

- (3) No symptoms in shoulder prior to accident.
- (4) Adequate injury—usually a fall
- (5) Immediate sharp, brief pain
- (6) Severe pain on following night
- (7) Loss of power in elevation of the arm
- (8) Negative X ray
- (9) Little, if any, restriction when stooping
- (10) Faulty scapulo humeral rhythm
- (11) A tender point,
- (12) a sulcus, and
- (13) an eminence
- (14) at the insertion of the supraspinatus,
- (15) which cause a jog
- (16) a wince and
- (17) soft crepitus as the tuberosity
- (18) disappears under the acromion when the arm is elevated, and usually also as it reappears during descent of the arm

TREATMENT

Codman says if the above syndrome is present he feels that 'not only is exploration indicated but that it should be strongly urged, for immediate suture should be a simple and successful operation. Delay means retraction of the tendon and a much more serious problem'

The ruptured tendon should be repaired by operation unless the tear is too small to disturb the function of the joint or the general condition of the patient is such as to render an anaesthetic dangerous

The arm is in such cases immobilized in an abduction frame with the arm abducted 90 degrees and laterally rotated 60 degrees for about ten weeks

The Operation The bursa and tendon are explored through a 5 inch incision which extends downwards from the acromio clavicular joint and separates the deltoid fibres

In view of the herring bone connection of the fibres of the deltoid it is easier to approach the shoulder joint between the deltoid and the pectoralis major, elevating part of the deltoid from the acromion to get access. After the bursal cavity is entered, the under surface of the acromion may be inspected if the wound edges are strongly retracted and the arm pulled down. By rotating the arm the tuberosities with their attached tendons can now be examined. When the tendon is ruptured, a gap is present in the capsule through which the articular cartilage of the head of the humerus is visible. The humerus is abducted to approximate the torn fibres and several mattress sutures of very strong chromic gut or silk are used. The broad band of supraspinatus tendon is stitched to the tuberosity itself through which the heavy needle employed is passed after six or seven drill holes have been made in its outer furrow so that cutting out from the short distal fibres is avoided. An abduction splint is worn for four to six weeks until the patient can lift and hold the arm

RECURRENT DISLOCATION OF THE SHOULDER JOINT

A patient who periodically dislocates the shoulder joint is considerably handicapped. The limb loses much of its power and efficiency, and each recurrence is painful so that the individual lives in constant dread. With each dislocation less and less force is required, and whereas at first reduction necessitates the aid of a surgeon, later on the patient is able to restore it himself. The recurrences may eventually occur at intervals of a few weeks and may be accompanied by relatively few symptoms. Nevertheless, the ever present danger from falls, and the disabling effect of the dislocation on work and play, call for active treatment. The derangement occurs most frequently in athletes and in epileptics, between the ages of 20 and 30 years.

Most of the bony and muscular factors, hitherto thought to be the cause of the disability, appear to have little etiological significance and, in fact, Bankart believes that the only essential lesion is a detachment of the *glenoid ligament from the anterior margin of the glenoid cavity*. The recurrent dislocation is different in its cause and results from an ordinary traumatic dislocation—the commonest of all dislocations. The latter occurs from a fall on the abducted arm and the head is forced through the weakest part of the capsule between the subscapularis and the triceps by leverage against the acromion. The recurrent type is produced by a fall directly on the back of the shoulder or on the elbow which is directed backwards and slightly outwards. The humeral head is forced anteriorly out of the joint and shears off the fibrous or fibro cartilaginous glenoid ligament from its anterior attachment to bone. This defect does not heal since there is no tendency for the ligament to become attached to the bone, and so the head is free to move forwards out of the joint.

The dislocating head may show a notch on its posterior border close to its articular margin where, when it dislocates, it comes in contact with the anterior margin of the glenoid.

SYMPTOMS

The dislocation eventually becomes painless, but many of the patients acquire a morbid, exaggerated dread of recurrence. Considerable muscular atrophy may be detected, particularly in the brachialis, the triceps, the deltoid and the supra- and infraspinatus.

TREATMENT

After the third recurrence it is unlikely that any treatment other than operative will suffice. If operation is contra indicated or refused, an appliance consisting of a chest belt and an upper arm band, fixed together by a small leather strap, may give relief. This prevents abduction, which is the primary cause of the dislocation, and it should be worn day and night. At night it may be more comfortable to stitch the sleeve of the pyjama coat to the body portion.

Operative Treatment.

Treatment by operation is advisable once the condition has become established. It has been reliably stated that 150 different operations have been devised to overcome recurrent dislocation of the shoulder. With few exceptions, these fall into three categories.

1 Operations on the capsule, in which some method of strengthening, such as reefing or overlapping, is employed.

2 Operations in which the aim is stabilization of the humeral head. In these some adventitious tissue, such as fascia, tendon, or transplanted slips of muscle is used to hold the head in position.

3 Operations on the glenoid in which the aim is to prevent dislocation by means of bony blocks.

While all these methods have undoubtedly proved effective on occasion, the criterion for the selection of any one should be simplicity combined with reliability. Only two operations will be described here.

1 The Bankart Operation.

2 The Nicola Operation.

The author has tried many operations, and though favouring Clairmont's deltoid transplantation at one time now attempts to do Bankart's glenoid refixation. Nicola's bicipital transposition is a valuable second choice.

(1) **The Bankart Operation.** Bankart believes that since the dislocation is due to the wide detachment of the glenoid ligament from the anterior margin of the glenoid cavity the operation should be directed to the repair of this defect.

The incision is made from the clavicle above the coracoid and extends for 5 inches down the anterior border of the deltoid muscle. This muscle is separated from the pectoralis major, avoiding the cephalic vein and exposing by retraction the coracoid and the muscles inserted into it. The coracoid process is now divided with an osteotome in a downward direction and its tip and the three muscles displaced downwards. On lateral rotation of the humerus the subscapularis is exposed and its tendon divided near its insertion into the lesser trochanter. The joint capsule is now visible. In every case Bankart states that the anterior margin of the glenoid cavity will be found to be rounded smooth and free of any attachments, and that a blunt instrument can be freely passed inwards over the bare bone on the front of the neck of the scapula. In some cases there is a wide opening into the joint with the glenoid ligament lying loose. If the capsule appears to be intact he says it should be incised near the glenoid margin and the narrow portion on the inner side of the incision raised. This outer cut edge is fixed to the glenoid margin. Before fixation a thin shaving of bone is raised by an osteotome from the front of the glenoid and neck of the scapula. While the humerus is drawn away from the glenoid holes may be perforated through the glenoid margin with sharp vulsellum forceps or towel clips. The edge of the capsule and glenoid ligament are now stitched to the perforations in the bare area over the

glenoid edge using silk worm gut or silk. The subscapularis tendon and the coracoid process are reconstituted, the skin closed and the arm bandaged to the side. The arm is kept so for one month. Active movements are then begun and a full degree of movement should be present in another month.

The difficulty in this operation is drilling the holes transversely on the glenoid edge situated as it is at a considerable depth in the wound.

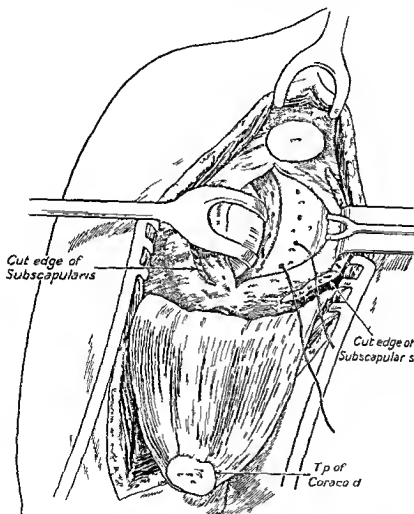


FIG 393—The Bankart Operation

The author uses an electric drill to drill directly backwards on either edge through the compact bone. When this hard bone is removed it is a much easier matter to complete the holes with towel clips. A metal staple may be used along with a special staple holder but it is difficult sometimes to get the capsule over the edge whereas with sutures it can be drawn over.

2 The Nicola Operation This operation has for its principle the retention of the head of the humerus within the glenoid fossa by means of the long tendon of the biceps, which is transplanted into a tunnel through the humeral head. A 5 inch anterior vertical incision is made about $\frac{1}{2}$ inch lateral to the anterior border of the deltoid muscle and the fibres of the muscle separated from the pectoralis major to expose the capsule near the bicipital groove. The tendon

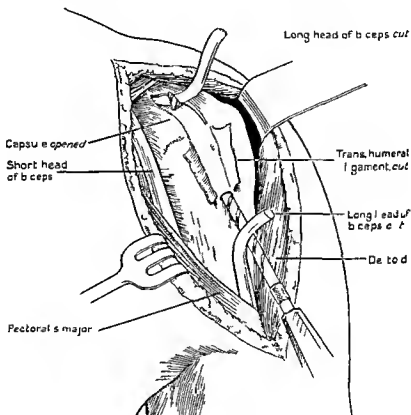


FIG. 374.—The Nicola Operation.

of the long head of the biceps is exposed by cutting the transverse humeral ligament over the tendon and splitting the capsule in the direction of the tendon. The bicipital branch of the circumflex artery which accompanies the tendon should be avoided. The long tendon of the biceps is divided between stay sutures 1 inch distal to the inferior margin of the transverse humeral ligament. Using a $\frac{1}{4}$ inch drill a hole is drilled through the head and neck of the humerus beginning in the bicipital groove about 1 inch distal to the lesser tuberosity. It is so directed that it comes out on the articular head of the humerus in

the line of the direction of the tendon about one half to three quarters of an inch from the edge of the articular cartilage. By means of a probe the cut end of the proximal tendon is drawn through the tunnel. The arm is now abducted to a right angle and the transverse humeral ligament is sutured to that part of the tendon lying in the bicipital groove. This ensures there being enough tendon to allow abduction and it also holds the tendon and prevents its movement in the artificial tunnel. The transverse humeral ligament and the capsule are sewn with a continuous No. 1 plain catgut suture and the skin closed. The arm is put up with adhesive plaster with the elbow flexed to 45° and left so for three weeks. The patient is then allowed to resume movement gradually, massage, gentle movements and heat being advisable. The patient is cautioned not to abduct his arm completely for at least eight weeks.

RECURRENT DISLOCATION OF THE ACROMIO CLAVICULAR JOINT

The clavicle may be dislocated either upwards or downwards at the acromio clavicular joint the upward dislocation being more common on account of the slope of the joint surfaces. The displacement results from a blow on the back of the acromion, or from a fall on the tip of the shoulder. It is thus a common football injury but since it is as a rule incomplete it rarely requires treatment as spontaneous reduction usually occurs. When the upward dislocation is complete the acromio clavicular ligament and the conoid and trapezoid ligaments which hold the clavicle down to the coracoid, are ruptured and the lateral end of the clavicle slides upwards and projects. As a result there is considerable deformity, some difficulty in lifting the arm, and limitation of certain of the shoulder movements. The condition is recognized by the nature of the causative injury, by the well marked projection in the region of the joint, by the localized tenderness over the joint, by the pain elicited in the same situation when the shoulder is moved, and by an X ray picture.

If reduction has not occurred spontaneously, it can be secured easily by raising the arm and by manipulating the joint. The reduction however, though easily obtained may be difficult to preserve, especially if coraco clavicular ligaments are ruptured. The best immediate measure is by means of a brachio clavicular sling. Broad strips of adhesive plaster are passed round the elbow and over the top of the shoulder the strips being joined by a piece of strong elastic tubing. The wrist is supported by a separate bandage sling. This method is really a modification of an old one whereby a sling was passed under the flexed elbow and tied over a pad placed on the acromio clavicular joint.

If these immediate measures are unsuccessful, and the dislocation

recurs, operative treatment should be considered. It is rather doubtful if the operation is worth the patient's time and trouble, for even with a permanently dislocated acromio clavicular joint the eventual disability is not very great. If operation is undertaken it is necessary to fix the clavicle to the coracoid process, for it cannot be fixed to the acromion sufficiently strongly. The ideal material for binding these bones is fascia, as it is a natural binding agent, hypertrophies under conditions of normal tension, allows normal motion in the joint, and 'lives' as long as the patient.

The joint is exposed by a semi lunar incision, with its convexity forward. The coraco clavicular ligaments are now reconstructed by means of fascia lata. The upper surface of the clavicle immediately

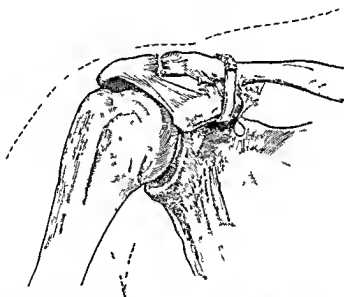


FIG. 320.—Stabilizing Operation for Acromio Clavicular Dislocation. Fascia is used and after insertion is tightened and the two ends sutured together.

above the coracoid is denuded of periosteum and the coracoid exposed sufficiently to allow a loop of fascia to be passed round it. One end of the loop goes behind the clavicle, the other in front. The dislocation is now reduced by pushing the arm upwards, i.e. pushing the coracoid up towards the clavicle, and while the reduction is maintained the loops are united by means of braided silk. In this manner the clavicle is held firmly in position. A plaster of Paris cast is now applied while the involved shoulder is held as high as possible to relieve the strain on the repaired ligament. The cast extends from the iliac crest up to the axilla on both sides and includes the arm and forearm on the affected side. It is removed in six weeks and full function should be restored in three months.

DISLOCATIONS OF THE MEDIAL END OF THE CLAVICLE

Dislocations of the medial end of the clavicle are rare as the bone breaks easily and the ligaments supporting the articulation are strong. In particular, the rhomboid ligament (costo-clavicular ligament) stretching from the clavicle to the front of the costal cartilage is very strong and resists the tendency of the clavicle to slip upwards medially and forwards in the line of slope of the joint cavity. The dislocation is usually an anterior and medial one on this account and when complete there must be rupture of the costo clavicular ligament. Subluxation may occur if the capsule and ligaments stretch without completely breaking.

Posterior dislocation may be caused by direct violence but is fortunately rare, as the displaced clavicle in this case may injure the large vessels in the superior mediastinum.

Subluxation can usually be reduced by direct pressure over the clavicle while the shoulder is simultaneously elevated strongly and carried forwards. After reduction, the joint may be retained in position by a sling which keeps the elbow forced upwards, combined with a felt pad over the joint secured in place with adhesive strapping. This treatment, in the case of a complete dislocation, should be kept up for four to six weeks to allow the avascular ligament to heal.

In the posterior dislocation manipulation is usually ineffective, and the reduction must be made by open operation the clavicle being replaced by the use of some form of lever. In this case some means of fixing the clavicle must be employed. Thin metal or fascial sutures may be used, or the meniscus may be stitched to the front of the capsule, or the clavicle to the first costal cartilage. The author favours the use of fascia lata employed as a mattress suture after parallel tunnels have been drilled in the sternum and the clavicle.

If a recurrent anterior dislocation causes severe symptoms a similar type of operation may be employed, or the clavicle may be sutured to the first costal cartilage by a loop of fascia lata in a similar way to that employed in recurring acromio clavicular dislocation. In this method the fascial suture replaces the ruptured costo clavicular ligament.

Bankart has recently described an operation which he states has been very successful in his experience. By means of a four inch incision along the inner end of the clavicle and over the sternum the dislocated bones are exposed. A flake of bone about half an inch long is raised by a periosteum elevator from in front of both bones and turned downwards. After the insertion of the sterno mastoid is freed the posterior aspect of the joint is exposed by blunt dissection and protected by a broad spatula while two holes are drilled in an antero posterior direction through both bones. A strip of fascia lata is now threaded through the clavicular holes from behind, leaving the two loose ends in front. These

ends are now taken through the joint in a backward direction and brought through the sternal holes from back to front. The dislocation is now reduced and the fascia pulled tight, tied in a single knot, stitched with linen thread and then the reef knot in the fascia completed. By further linen sutures and replacement of the bone flakes a secure fixation is obtained. The arm is kept bandaged to the side for one month.

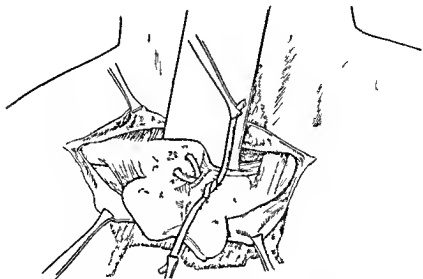


FIG. 36 The Bankart Operation for Recurrent Dislocation of the Sternoclavicular Joint

DISLOCATION OF THE BICEPS BRACHII

This condition has been recognized since the time of Hippocrates. The tendon is retained in position mainly by the attachment of the articular capsule in the region proximal to the lesser tuberosity and by the medial ridge of the bicipital sulcus which is often very deep. Meyer does not believe that the transverse ligament is important in retaining position. The capsule of the joint may stretch and allow the tendon over the lesser tuberosity and since the tuberosity is rough wear of the tendon and even rupture may occur. A localized osteitis reduces the volume of the lesser tuberosity and favours luxation. It is probable that violent muscular action may dislocate the tendon. When the tendon slips over the lesser tuberosity the tension of the muscle is immediately lessened and the classical bicipital syndrome results.

The symptoms in most cases are similar to those of a ruptured biceps tendon and the onset is acute. There is pain in the region of the bicipital groove which may radiate down the muscle. The pain is increased on external rotation and overhead extension while weakness

in the arm is marked and function impaired. The muscle belly is flabby and lower than the normal position. It is unusual to be able to palpate the empty groove but a change in direction of the tendon is more easily detected. If the onset has been gradual or the slip is only slight the symptoms and signs are not very striking.

Diagnosis is not always easy but in any disability of the shoulder brought on by a sudden movement or by movement of external rotation and overhead extension and continued over a long time, the possibility should be considered. The patient can often produce the dislocation by bringing his extended arm to overhead extension and external rotation holding a 5 lb weight in each hand. The observer puts his finger on the tendon and may feel the snap and often hear it. It is like a taut violin string that snaps as it slips into the groove of the bridge.

To reduce a dislocated tendon Gilehrst suggests that the extremity with the elbow bent and the forearm supinated in order to relax the tendon should be abducted passively and gently in the correct plane to 90 degrees or more brought forward and simultaneously rotated internally. He says the surgical repair varies with the findings. If possible the structures round the groove should be repaired and the groove deepened. An easier procedure and a satisfactory one he says is to repair the tear in the structures round the groove after severing the tendon of the long head as high in the joint as possible and then to suture this tendon to the coracoid process and to the tendon of the short head.

SNAPPING SHOULDER

An audible click or snap may be produced by certain movements of the shoulder joint. It may be the result of a voluntary subluxation of the shoulder joint or be due to a tendon slipping over a bony prominence e.g. the short tendon of biceps over the lesser tuberosity. The condition is not common but Kappas has reported thirteen cases of 'shoulder snappers'. The sound occurs usually when the joint is voluntarily brought to an abnormal position in which it has been pushed backwards under a stretched muscle. The phenomenon may ultimately become habitual or involuntary. The muscles responsible vary in different cases but there is almost invariably some weakness of the deltoid. Sometimes the patient can reproduce the condition on request and following the audible snap the shoulder is immediately painful. Bristow has reported a case in which he found abnormal muscular fibres arising from the lateral side of the short head of the biceps, and passing downwards and laterally towards the long head. He was able to demonstrate at operation that abduction and rotation of the arm caused these fibres to ride over the lesser tuberosity. Removal of a part of this muscle which apparently corresponds to the rotator humeri of lower mammals was followed by a cure.

Kaffis suggests that where repeated acromio clavicular dislocation is

the cause of the condition, an arthrodesis of the joint would relieve it, in actual practice, however, he prescribes no treatment, as ankylosis interferes to a great extent with the function of the shoulder, and in any case the error disappears with diminished use of the muscles

SNAPPING SCAPULA

Scapular grating or snapping the expression of some anomalous condition between the ribs and the under surface of the scapula, is a tactile acoustic phenomenon which has been observed in varying intensity in different persons. In some there may be a loud snap, while in others there is only a fine grating barely perceptible to the touch. It appears that the causes of these sounds may be divided into three main groups

(a) those due to changes in the bony structure of the under surface of the scapula or of the wall of the chest,

(b) those due to changes in the musculature intervening between the scapula and the wall of the chest,

(c) those due to changes in bursæ normally or abnormally present between the scapula and the wall of the chest

A Bone Causes In the category of cases due to changes in the bony structure of the scapula or the chest, a number of sub groups has been denoted

1 The tubercle of Luschka—a small bony or fibro cartilaginous elevation located in the anterior aspect of the superior angle of the scapula at its largest the size of a pea, usually covered by a bursa, was first described by Luschka. It appears to be a matter of doubt whether this is ever a cause of scapular snapping

2 Abnormal curvature of the superior angle of the scapula. This is apparently of congenital origin

3 Scapular snapping has been noted in the presence of exostoses on the ribs or on the under surface of the scapula. The exostoses may be found either at the superior or inferior angle of the scapula, and may vary in size from osteo cartilaginous nodules to relatively large mushroom shaped masses

4 Tumours of the ribs or scapula fracture of either angulation or buckling of the ribs are all possible causes in the osseous group

B Muscular Causes The second main group is that associated with changes in the muscles lying between the scapula and the ribs. Voelker suggested that a lesion in the muscles similar to tendonitis crepitans might be responsible for this type of snapping

C Bursal Causes The third main group is that in which scapular snapping has been attributed to the presence of normal or adventitious bursæ. Normally two are present beneath the scapula. one at the upper angle situated in the depth of the serratus anterior muscle, is present in about one in every eight persons. The other, somewhat

rarer, is found in the connective tissue between the serratus anterior and the upper part of the lateral wall of the chest

Hendriks reported a case in which he believed the sound was caused by an inflammation in one of the sub scapular bursæ while Jacoby reported a case in which the X ray picture showed two irregular shadows beneath the level of the scapular spine

For the most part only conservative treatment need be instituted but when there are definite bony changes for example excessive forward bending of the scapula and exostoses surgical removal of the offending part should be undertaken

CHAPTER XX

AFFECTIONS OF THE KNEE JOINT

No other joint in the body so frequently suffers derangement of its function and its stability as the knee joint and its complicated mechanism and intricate structure make accurate diagnosis of its many disabilities difficult and uncertain.

The manifestations of acute trauma and infection do not materially differ from those in other joints. When these are excluded there remains a series of conditions chiefly mechanical which interfere with the efficient action of the joint.

The term *Internal derangement* was originally applied to these lesions in 1803 by William Hey. In his *Practical Observations on Surgery* he thus defines them: "The complaint I have described may be brought on by any such alteration in the state of the joint as will prevent the os femoris from moving truly in the hollows formed by the semilunar cartilages and the articular depressions on the tibia."

It was originally presumed that the lesions were all intra-articular; hence indeed the form of Hey's description. An increasing knowledge of the pathology of the joint now indicates that certain of these mechanical derangements may in fact be extra-articular. With the realization of this fact the number of conditions now alleged to give rise to this type of disability has grown to almost terrifying proportions.

Many of the lesions fall into the group of occupational injuries—e.g., the cartilage displacements so common in miners—while others are common in those who indulge in certain forms of athletics. Their importance to the orthopaedic surgeon is great since disturbances in the function of the knee are increasingly common and since treatment at least in the early stages is often associated with complete relief.

A CONSIDERATION OF THE ANATOMY OF THE KNEE JOINT

The knee is the largest joint in the body and its security depends not on the intrinsic shape of its articular surfaces as in the hip but on the series of powerful ligaments which bind the component bones together and on the muscles which surround it.

The Medial and Lateral Ligaments. The *medial ligament* is a flattened band attached proximally to the femur and inserted below

into the antero medial aspect of the tibia. It strengthens the capsule on the medial side, and has a close and important relationship to the medial semilunar cartilage. Fisher has shown that the ligament is composed of two parts.

(1) An anterior portion consisting of long fibres running between the tibia and the femur which are only loosely attached to and readily separated from, the semilunar cartilage.

(2) A posterior part, with short fibres which is closely bound to the semilunar cartilage a little behind the mid point of its periphery.

It is obvious that in this peculiarity in the anatomical disposition of the ligament there is a state of affairs which can readily give rise to trouble since, as Fisher has so ably pointed out. A mechanical weak spot exists where the movable anterior portion joins the comparatively fixed posterior portion of the cartilage.

The lateral ligament stretches between the femur and the head of the fibula but has not the same close association with the lateral semilunar cartilage, the tendon of the popliteus intervening between the two.

These ligaments resist undue lateral movements of the joint, and since exaggerated lateral movements are of frequent occurrence in many types of injuries the ligaments are often torn or damaged.

Behind the joint capsule is reinforced by a thickening known as the posterior ligament. It consists of an expansion of the semimembranosus tendon, and forms the floor of the popliteal space.

The Semilunar Cartilages (Menisci) The semilunar cartilages are crescentic portions of fibro cartilage arranged round the periphery of the upper articular surface of the tibia. On cross section, the cartilages are wedge shaped the thin apical portions of the wedge being directed towards the centre of the joint. Along with the tibial spine the cartilages form two hollows or depressions for the more accurate reception of the rounded femoral condyles than could be provided by the flattened articular facets of the upper end of the tibia.

1 Medial Semilunar Cartilage The medial semilunar cartilage is larger and more oval than its fellow. It is attached by two horns or cornua to the anterior and posterior parts of the non articular surface on the upper end of the tibia. The horns of the lateral semilunar cartilage lie within the embrace of those of the medial, and occasionally the anterior extremities of the two cartilages are united by the so called transverse ligament.

Of great importance in the anatomy of the medial cartilage is its relation to the medial ligament.

2 Lateral Semilunar Cartilage The lateral semilunar cartilage is more circular and its horns are attached to the tibia one on each side of the tibial spine. The posterior horn has usually a strong ligamentous attachment to the posterior cruciate ligament.

There is a well marked groove on the peripheral aspect of the cartilage just behind its mid point, where the popliteus tendon passes

across it. The tendon actually serves to prevent any degree of close attachment between the lateral semilunar cartilage and the lateral ligament, so that in contradistinction to the medial cartilage the lateral enjoys a considerable range of movement. Further it moves as a whole and there is no weak point between a movable and a fixed portion as there is in the case of the medial cartilage.

The two semilunar cartilages play an important part in the function of the joint. They further the adaptation of the tibial socket to the femoral condyles; they assist the collateral ligaments to check or prohibit exaggerated lateral movement of the joint (Tenney) and they help in the screw home movement of the knee.

Fisher has demonstrated an interesting feature pertaining to the nutrition and the vascular supply of the cartilages. He has shown that there are two nutritional zones in each, the peripheral is well vascularized whereas the central zone is practically devoid of blood vessels and derives its appropriate nourishment from the synovial fluid. Arguing from this basis it seems clear that given the appropriate chance healing may be obtained in wounds which are situated in the peripheral vascular zone of the cartilage whereas in the central zone repair is most unlikely.

The Relation of the Semilunar Cartilages to Movement of the Knee Joint

The knee is usually regarded as a hinge joint and indeed flexion and extension are its main movements. Its mechanism is not that of a pure hinge however for a certain amount of rotatory movement is possible at the knee. This takes place between the medial condyle of the femur and the medial semilunar cartilage, but only when the knee is flexed. When the joint has been subjected to long standing distensions and the capsule has become relaxed some degree of lateral movement may be acquired.

When the knee is in motion the femur may move on a fixed tibia or the tibia on a fixed femur. In all cases however, the cartilages remain in contact with and move with the tibial head although they possess in addition a small range of antero posterior 'gliding' movement.

A most important feature of knee movements is the "screw home" or locking action, which depends on the greater size of the articular facet on the medial condyle. Fisher gives the following excellent account of the mechanism.

It will be seen that the posterior two thirds of the medial condyle are equal in extent and parallel to the lateral, the anterior third however curves outwards towards the trochlear surface, and has no corresponding part upon the external condyle.

Let us imagine that extension is occurring the tibia acting as the fixed point. The femoral condyles glide and roll upon the upper

surface of the tibia and semilunar cartilages until the lateral condyle and the corresponding part of the medial condyle are used up. The remainder of the movement must occur at the expense of the curved anterior portion of the medial condyle and the femur accordingly rotates inwards round the tibial spine until the oblique portion is used up and at this point which corresponds to the termination of extension the joint is locked and the femur has been screwed home into the socket on the head of the tibia.

The Cruciate Ligaments The articular surfaces are also bound together by the two powerful cruciate ligaments. The anterior ligament is attached to the tibia immediately behind the anterior horn of the medial semilunar cartilage and passes upwards, backwards and laterally to be attached to the posterior part of the lateral condyle. The posterior ligament is attached to the tibia behind the posterior horn of the medial semilunar cartilage and passes upwards forwards and medially to the anterior part of the medial condyle. The anterior cruciate ligament is tense when the knee is extended and also when the femur is rotated medially on the fixed tibia. The posterior cruciate ligament is most tight in flexion.

It is often said that the cruciate ligaments normally prevent antero-posterior displacement of the knee joint. This is only partially true for in the extended position of the joint antero-posterior displacement is prevented by the normal screw home or locking mechanism and at other times the knee depends—as other joints do—on the protective influence of the surrounding muscles. It is significant in this connection that the knee is enfolded by an adventitious capsule provided by the muscles in the vicinity—the quadriceps and the semimembranosus particularly—so that the capsular ligament is largely under muscular control.

The Tibial Spine The articular surfaces of the tibial condyles are separated from each other by the tibial spine. In position therefore the spine corresponds to the intercondylar fossa of the femur.

The spine consists of two tubercles separated by an antero-posterior groove. The lateral tubercle is slightly smaller and some fibres from the anterior extremity of the lateral semilunar cartilage are inserted into it. The larger medial tubercle receives some fibres from the anterior cruciate ligament and occasionally the posterior horn of the lateral semilunar cartilage is attached to it. The size of the tubercles is liable to great individual variation.

The Infra patellar Pad An intracapsular but extra synovial pad of fat is situated behind the ligamentum patellæ from the main mass an extension passes backwards between the layers of a triangular fold which passes posteriorly from the anterior part of the synovial membrane at the distal part of the joint. The synovial prolongation is known as the ligamentum mucosum or patellar synovial fold and its delicate edges as the alar folds or ligaments. The fatty extension

is known as the alar pad or as the semilunar extension of the infra patellar pad

The importance of these anatomical features lies in the fact that hypertrophy of the alar pad is often difficult to distinguish from lesions of the cartilage while hypertrophy of the main infra patellar pad is a common form of internal derangement

INJURIES AND DISPLACEMENTS OF THE SEMILUNAR CARTILAGES

Lesions of the semilunar cartilages—usually the medial—constitute by far the largest number of internal derangements of the knee Platt for example when analysing a series of 268 knee conditions upon which he had operated found that no fewer than 232 showed lesions of the cartilages and in 185 of these cases the medial was affected But Naughton Dunn analysing the published writings of other authorities found that the ratio varied between 15 to 1 and 4 to 1 His own statistics gave a ratio of 2.6 to 1 This low ratio appears to be more acceptable in the present state of our knowledge

THE MECHANISM OF THE DERANGEMENT

(a) *The Medial Semilunar Cartilage* Normally the medial semilunar cartilage or at least its anterior movable portion—glides slightly backwards towards the interior of the joint as the knee is flexed If the joint is at the same time abducted and the medial compartment of the knee thus opened up the mobility of the cartilage is still further increased and a correspondingly greater part of the cartilage slips under the femoral condyles Sudden medial rotation of the femur on the fixed tibia is then liable to result in injury to the cartilage the exact type of lesion depending on the behaviour of the medial ligament The medial rotation causes the ligament to become taut and the ligament at first steadies the posterior part of the cartilage If the ligament withstands the strain therefore the anterior movable part of the cartilage bears the brunt of the injury It may either be detached at its junction with the fixed part or it may undergo any variety of transverse or oblique tear The fragment slips into the interior of the joint and when extension is attempted and an endeavour made to screw the condyle home the fragment is nipped or impacted between the condyles and the joint locks

When the rotatory strain is very severe the medial ligament may be so stretched that the connection between it and the cartilage is destroyed Indeed the ligament may be detached both from its tibial attachment and from the cartilage In either event the whole cartilage slips into the interior of the joint and as extension occurs the free border is caught between the condyles a longitudinal slit occurring in the substance of the cartilage To this latter type of lesion the apt description *bucket handle tear* is applied

Displacements or splits of the posterior end are caused by forcible lateral rotation of the femur on the fixed tibia combined with flexion

(b) **The Lateral Semilunar Cartilage** The lateral semilunar cartilage is less frequently injured than the medial since it normally enjoys a greater range of movement and is not attached to the lateral ligament. Nevertheless severe degrees of violence may result in tears or displacements

The anterior horn may be torn if the femur is forcibly rotated outwards on the fixed tibia when the knee is flexed. medial rotation of the femur on the fixed tibia combined with or followed by violent flexion is liable to cause a lesion of the posterior horn

Injuries to either of the cartilages occur only when the knee joint is in a position of flexion. The reason for this is obvious—the cartilages are so firmly fixed to the head of the tibia that they follow that bone in all its movements. If however the knee joint is bent at the time of receiving the strain then a lateral or rotatory strain on the joint may easily displace the cartilage from its attachment to the tibia

PATHOLOGY OF SEMILUNAR CARTILAGE INJURIES

The commonest injury of a medial meniscus is the so called bucket handle tear. This injury consists of a longitudinal fracture through the substance of the cartilage the fractured portion being displaced into the centre of the joint while the anterior and posterior attachments remain intact (see Fig 327 C). Almost all the remaining lesions of the menisci consist of some form of bucket handle tear with or without modifications caused by subsequent trauma

For example a longitudinal fracture may also occur through the substance of the anterior third in which event one limb usually retains its attachment but the other is frequently mobile and slips into the joint cavity (Fig 327 B and D). A similar type of injury is found in association with posterior horn injuries (Fig 327 E). Further examples occur when the centrally displaced portion of a complete bucket handle tear is subjected to a further longitudinal split or is torn transversely leaving tags of cartilage projecting into the centre of the joint from the anterior and posterior horns

In a proportion of cases no organic lesion is present but the posterior half or the anterior half (Fig 327 A) or even the whole cartilage loses its peripheral attachment and slips into the cavity of the joint with each movement. Such injuries are merely examples of bucket handle tears—the tears taking place immediately external to the periphery of the cartilage

The operative findings in the case of the lateral semilunar cartilages are essentially similar but in addition the cartilage may undergo cystic degeneration (see Semilunar Cysts). Degenerative cystic change is rare in the medial meniscus

AFFECTIONS OF THE KNEE JOINT

CLINICAL FEATURES OF DISPLACED OR TORN MEDIAL SEMILUNAR CARTILAGE

Predisposing Factors The anatomical factors which appear to favour the occurrence of cartilage lesions were freely discussed in a section dealing with the anatomy of the joint. Reference may now be made to certain *occupational factors*.

Lesions of the cartilages are most common in miners and particularly in those who have to work a low seam of coal. These men have to stoop or squat at the low coal face when hewing so that their

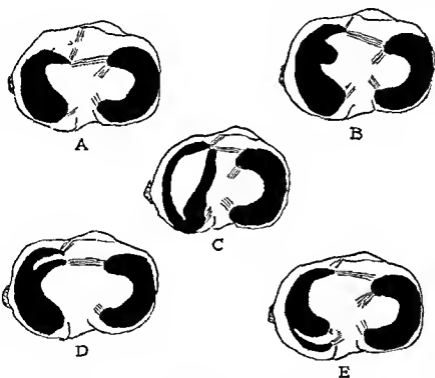


Fig. 32.—Derangement of the Medial Semilunar Cartilage. (A) Avulsion of the anterior horn. (B) Local hypertrophy after a crushing injury. (C) Bucket handle type of injury. (D) Split anterior horn. (E) Avulsion of the posterior horn.

knee joints are constantly flexed when they wish to clear away the coal they must while still in the squatting position empty the shovel over the shoulder. To perform this acrobatic feat the body must be rotated, the knee joint slightly abducted and the femur medially rotated. The medial cartilage accordingly slips in between the articular surfaces and if the miner suddenly extends the knee the cartilage may be unable to escape in time and so becomes crushed or torn.

Certain forms of sport are commonly associated with cartilage injuries. Footballers are liable to them especially when the ball is

kicked with the inner side of the foot. Impact then takes place with the knee in a flexed position, the force of the impact causes a certain amount of lateral rotation of the tibia on the femur, and the follow up of the kick extends the knee. Cricket, hockey, tennis, badminton, squash rackets, and skiing—all games in which a sudden twist of the knee is liable to occur—also supply a considerable proportion of patients.

Certain pathological conditions predispose to cartilage disorders

In long standing cases of genu valgum the medial ligament may be considerably stretched and the attachment of the cartilage correspondingly weakened.

Recurrent synovitis, leading to repeated distension of the capsule, is associated with relaxation of ligaments, among them the medial ligament, again in these cases the cartilage acquires unwonted mobility.

SYMPTOMS

An accurate and detailed history is essential, and its importance is equal to that of the clinical examination. The events from the time of the original injury should be carefully recorded in their exact sequence. It is particularly important to discover whether or not the joint was injured by some external force.

The usual history in a case of displacement of the medial semilunar cartilage is as follows. With the knee in a position of flexion the patient sustains a sudden outward twist of the foot—or it may be an inward twist of the femur—and immediately feels an acute pain in the antero-medial part of the joint, so severe as to cause him to fall to the ground or even to faint. On attempting to rise, straightening of the knee may or may not be possible according to whether the cartilage has remained displaced or has slipped back to its normal position. This trauma is followed in a few hours by swelling in the joint which disappears in the course of a week or so.

The pain is situated over the anterior end of the cartilage, and frequently also over the inner border of the tibia, where the short posterior fibres of the medial ligament are normally attached. In posterior horn injuries the pain is more marked on the posterior aspect of the joint.

In recurrent cases the symptoms are less severe than those which accompany the original injury. Locking often occurs but may be only momentary and accompanied by little pain. The patient in these cases generally learns how to replace the cartilage himself, or to instruct others how to do it.

In an injury of the lateral semilunar cartilage the history is similar except that the knee is twisted in the opposite direction and the pain is on the lateral aspect of the joint. Locking from injury to this cartilage is rare, and there is a uselessness or feeling of weakness rather than painful locking in subsequent displacements. Often in the case of the lateral cartilage there is an additional sign of clicking felt and some

times heard as the joint is straightened. McMurry points out that there are two important points to be noted in regard to this diagnostic click. (1) it always occurs at the same angle of flexion of the joint and (2) this angle is usually the last ten degrees of full active extension.

THE EXAMINATION

The patient is examined with the lower limbs bare and the knees are inspected anteriorly and posteriorly in both the upright and recumbent positions. The joint is often swollen from chronic synovitis and the swollen appearance accentuated by atrophy of the quadriceps. There may be a depression over the anterior end of the cartilage or an external prominence at this point.

In addition to the above palpation usually reveals definite tenderness over the anterior attachment of the cartilage. This is well brought out by the following test. The thumb is placed on the medial side of the ligamentum patellæ with the knee in flexion, as the joint is slowly extended the anterior end of the cartilage comes into contact with the thumb and the patient experiences pain. There may also be tenderness over the tibial attachment of the medial ligament.

Movements In unreduced cases the joint can neither be fully flexed nor extended. In old standing cases there is often a certain amount of lateral mobility due to laxity of the medial ligament. In lesions of the posterior horn there is sometimes a well marked click or snap accompanying rotation when the knee is extended.

X ray Examination

This should be a routine part of the clinical examination. It is essential for accurate diagnosis and operation should never be undertaken without it.

DIAGNOSIS

When there is a definite history of a twisting injury causing the knee to give way followed by locking and synovitis the diagnosis presents no difficulty. These classical signs and symptoms



FIG. 38—Calcification of the Lateral Semilunar Cartilage

usually indicate a lesion of the anterior end of the medial semilunar cartilage. The signs of a lesion of the middle or posterior end of the medial cartilage or a tear of the lateral are less obvious but equally typical. McMurray has pointed out that the site of a lesion depends to some extent upon the angle of flexion of the joint at the time of the occurrence of the original injury thus if the joint is slightly flexed the lesion is usually towards the anterior end while the more the joint is flexed the further back is the lesion. At mid flexion and beyond it the damage to the cartilage is not usually gross enough to cause locking but when it is nipped between the femur and tibia it causes pain and discomfort and a transitory weakness frequently followed by synovitis.

It has been pointed out that if it is possible to manipulate the joint so that the injured part of the cartilage is nipped between the bones pain similar to that usually experienced is felt. This may be a useful test therefore when locking is absent and diagnosis obscure. McMurray has described the details of the manipulation. The knee joint is first fully flexed so that the heel is placed almost on the buttock. Abduction of the leg and lateral rotation of the foot will bring to bear on the medial semilunar cartilage a strain similar to that which produces the ordinary lesion. With the foot and leg held in this relation to the thigh the knee is slowly extended. If there is a lesion of the cartilage at any point from the level of the attachment of the tibial collateral ligament to the posterior horn a distinct click will be produced when the femur passes over the site of injury as the cartilage is usually thickened or loose. The patient also complains of a stab of pain as the click takes place.

The X ray film should eliminate such bony conditions as fracture of the tibial spine, loose body, exostosis, osteoarthritis, myositis ossificans and intra articular fracture.

DIFFERENTIAL DIAGNOSIS

When accurate diagnosis is difficult the following possibilities have to be excluded.

1 Injury to the Alar Pad of Fat. True locking is absent although full extension is painful. Tenderness can be elicited by pressing on the pad and a sensation may be experienced of something slipping between the fingers.

2 Rupture of the Medial Ligament. The trauma in this case is abduction in extension rather than rotation in flexion. There is no history of locking.

Tenderness is present over the femoral or tibial attachments or in the line of the ligament. Undue lateral mobility is found.

It must be remembered however that from their anatomical relationship injury to the medial collateral ligament must predispose to injury of the medial meniscus. It is not until the acute symptoms of a medial

ligament injury have subsided that the injury to the cartilage becomes evident

3 Rupture of the Cruciate Ligaments. When the anterior cruciate ligament is ruptured, the tibia can be displaced forwards on the femur when the knee is fully extended. In the case of rupture of the posterior cruciate the tibia can be displaced backwards on the femur with the knee flexed to a right angle. If these findings are obtained a careful comparison should be made with the sound side, as many individuals possess an unduly mobile knee.

4 Fracture of the Tibial Spine This injury is the result of more severe violence and does not follow a simple rotatory strain. There is no tenderness over the attachments of either cartilage. Locking if present takes the form of a bony block to complete extension. The fracture is usually obvious on radiographic examination.

5 Loose Bodies The locking which is produced by a loose body is usually momentary and is not inaugurated by any special movement. The situation of the pain may vary with each attack, unless the body is pedunculated. In most cases a radiograph reveals the condition.

6 Exostosis An exostosis in the region of the knee joint may so interfere with the free action of the tendons that "locking" may be simulated. Pain is usually felt over the exostosis which can usually be palpated and can always be seen in radiographs.

7 Osteo-arthritis The onset is usually gradual. Pain and stiffness are marked in the morning but disappear in the course of the day. Both the pain and tenderness are diffuse and not confined to any particular part of the knee. The lifting of the articular margin can usually be recognized on palpation, and demonstrated by X rays.

8 Recurrent Dislocation of the Patella It is not always easy from the history alone to exclude the possibility of this lesion. The joint however is not usually tender, the quadriceps is lax and when the knee is extended it is usually possible to displace the patella over the outer femoral condyle.

TREATMENT

1 Treatment of the Original Lesion

Certain rules are applicable to all cases.

(a) Reduction must be accurate.

(b) It must be maintained until the torn cartilage has healed.

(c) The damaged structures must be guarded from strain or further injury for some months.

(d) During this period the nutrition of the joint structures and tone of the related muscles must be preserved.

The Methods in Detail

(a) **The Reduction** Reduction should be performed at the earliest possible moment in many cases an anæsthetic is an advantage but it can often be dispensed with

In the case of the right knee the surgeon stands on the right side and grasps the patient's right foot firmly with his right hand steady ing the knee with his left hand The knee is first fully flexed the leg is then abducted and at the same time rotated first laterally and then medially While in this position it is suddenly extended an audible snap may be heard indicating that the displacement has been reduced A good test of reduction is the ability of the patient to extend the knee fully and painlessly by his own effort and maintain it in that position If a second attempt is necessary it should be carried out under an anæsthetic

(b) **The Retention** No splint is necessary The joint is immobilized and firm compression applied by means of a Jones' bandage—several layers of wool between turns of a broad doinette bandage This both prevents the occurrence and facilitates the absorption of an effusion

On the second day the patient begins quadriceps drill—straight leg raising and rythmical contraction of the extensor apparatus This is practised five minutes per hour throughout the waking day

On the tenth day active flexion may be permitted and on the fourteenth day the patient becomes ambulatory

(c) **Prevention of Strain** Abduction and lateral rotation of the leg on the thigh should be avoided for some months The simplest method of ensuring this is to raise the inner side of the heel and sole of the boot by a wedge of leather The patient should also be taught to walk with the feet parallel or even with the toes turned inwards

(d) **After Treatment** Quadriceps volume tone and control must be maintained and improved by the continuous practice of quadriceps exercises Massage and faradic stimulation are in common use but are no substitute for active quadriceps exercises

PROGNOSIS

It has been stated previously that only the peripheral zone of a meniscus is vascularized It therefore follows that healing may be expected in bucket handle tears at the extreme periphery of the cartilage in tears entering the synovial attachments and in injuries where the anterior or more often the posterior horn is detached from the capsule of the joint The major portion of cartilage injuries however do not fall into this group

In general it may be stated that the prognosis is good in patients who pursue a sedentary occupation Recurrence of symptoms may be expected in the majority of cases engaged in manual occupations or who continue active participation in sport

2 The Treatment of Recurrent Cases

(a) **Conservative Treatment by a Knee Cage** In some cases the locking and the giving way of the knee may be prevented by the use of a knee cage which permits flexion and extension but prohibits rotatory and lateral movements. The method is tedious and unreliable and operation is preferable unless there is some strong contra indication. The usual knee cage consists of a pair of leather supports 5 inches wide which encircle the thigh and the calf. They are connected by two collateral bands of metal each hinged opposite the knee joint the joint being on a plane slightly posterior to that of the medial ligament. If the calf is not well developed the outer steel support should be prolonged down to the heel, to prevent the cage from slipping down.

(b) **Treatment by Operation** In the majority of cases of recurrent displacement where there is a history of true locking and synovitis operation is the treatment of choice and should be undertaken at an early date to prevent the development of arthritic changes.

Opinion differs as to the necessity for the removal of the complete cartilage and some observers content themselves with resection of the damaged or loosened portion. There is considerable evidence to condemn this practice. In the first place those with a large experience of this operation find that if the posterior part of the cartilage is left it frequently gives rise to synovitis and a feeling of weakness and insecurity in the knee which may give way at unexpected moments. It would appear obvious that once a cartilage has been mobilized to a point posterior to the lateral ligaments it must be entirely removed for interference with the peripheral attachments of the posterior half of the cartilage must increase its liability to slip towards the centre of the joint. The practice of removing the displaced portion of a bucket handle tear is also unreasonable because of the frequency with which multiple bucket handle tears are encountered and the inability of the operator to test the mobility or inspect the posterior half of the remaining peripheral portion of the cartilage.

It is interesting to note that following resection of a cartilage a new cartilage of fibrous tissue regenerates from the synovial membrane. When the posterior horn of the original cartilage is left in the joint the anterior horn regenerates and an insecure junction is noted between the regenerated anterior and original posterior horns.

Technique of Operation

Pre operative Treatment During the usual two days preparation of the skin the patient is taught the quadriceps exercises mentioned above i.e. straight leg raising and rhythmical contraction of the extensor apparatus. The rapid return of function following the removal of a cartilage depends on the volume tone and control of the quadriceps and as the exercises are begun on the day following operation

less difficulty is encountered if the patient learns the routine during the pre operative period

The Operation Rigid asepsis is essential. A tourniquet is necessary to prevent bleeding and permit a clear view of the various intra articular structures. Many incisions have been described, but of these only two need be mentioned

(1) A curved incision from the anterior edge of the medial ligament an inch above the joint level to the edge of the patellar ligament gives adequate exposure in most cases. It is roughly parallel to the course of the infrapatellar branch of the saphenous nerve and is therefore unlikely to damage it. Some incisions divide this nerve, so that a small area of anaesthesia over the tibial tuberosity is produced, and not uncommonly thereafter a painful neuroma develops

(2) A curved incision from a point midway between the ligamentum patellae and the medial ligament at the level of the apex of the patella to the anterior edge of the medial ligament on the antero medial aspect of the tibia. The author favours this approach, which was originally described by Timbrell Fisher but now prefers a short vertical incision to expose the posterior horn rather than the conversion of the incision into the U flap exposure of Fisher. Two separate incisions heal more rapidly than the U shaped incision, the blood supply at the apex of the curve being of necessity precarious

The knee is flexed over the end of the operating table and the surgeon sits facing it. The part is completely covered by a square of muslin wrung out in biniodide in spirit solution. After the skin is divided a straight incision is made in the capsule some way in front of the medial ligament. The actual entrance to the joint cavity should first be made over the femoral condyle, since if it is made over the intercondylar fossa negative pressure on the joint pulls the synovial membrane inwards away from the knife. The extra synovial fat and the synovial membrane are divided together. The cartilage is then carefully inspected, and any abnormality such as a tear or undue mobility noted. The retropatellar pad of fat is next examined, and loose bodies, injuries such as fracture of the tibial spine or pathological processes like osteochondritis dissecans, excluded. If the anterior end of the cartilage is loose it is grasped with forceps. If not the anterior attachment is divided. Usually when there is a tear of the posterior part the whole cartilage can be pulled gently towards the interior of the joint when this is done. If the cartilage does not readily displace, its attachment to the medial ligament must be divided and the cartilage then dislocated. The division of the cartilage from the medial collateral ligament and of capsular attachments immediately posterior to the ligament are greatly facilitated by the use of the author's chisel type of knife. If the head of the tibia is then forced forwards by a sandbag behind its upper end and rotated by the operator's knees, the posterior horn can be divided by means of the chisel knife

It cannot be too strongly emphasized that when operation is under

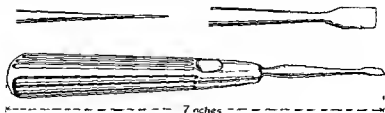


FIG. 329—Special cartilage knife

taken for torn or displaced semilunar cartilage the cartilage should be removed, even though on first inspection it appears normal. The condition of the posterior end of the cartilage cannot be determined on inspection from the front.

When there is difficulty in removing the posterior horn, which may occur in freeing the posterior third, it is of considerable value to divide the terminal attachment of the posterior horn to the bare area of the tibia as a preliminary step at this stage. One changes the locus of one's operative work from the medial part of the posterior third to the lateral part lying below the intercondylar fossa. The cartilage immediately becomes more mobile and with the tibia levered forwards over the sandbag it can be removed by dissecting and cutting again at its medial end.

Should it still be difficult or should the anterior horn be cut away alone, leaving the posterior horn, a second small vertical incision is made in the skin behind the medial collateral ligament. After incising the capsule in the same line the posterior horn can be seen and its attachment divided under vision. The whole cartilage can be withdrawn through this posterior capsular wound (Fig. 330).

In closing any of these incisions the capsule and the aponeurosis are approximated separately with linen thread and finally the skin edges closed. A firm pressure bandage should be applied before the patient leaves the operating table, and before the tourniquet is removed. This is very necessary, as it prevents post-operative effusion of blood into the joint. A splint is not required.

Post-operative Treatment. On the day following operation the patient begins the quadriceps exercises he has learnt during the pre-operative period. The bandage is not removed until the eighth day when the stitches are removed. On the tenth day the patient becomes ambulatory with the knee supported by a Jones' bandage if there is any marked effusion. Thereafter a progressive increase of active exercises is permitted.

PROGNOSIS

The majority of writers are agreed that perfect results are obtained in fully three quarters of the cases of removal of a semilunar cartilage. Symptoms may persist after operation in the remainder and probably the most frequent cause of this is osteoarthritic change in the joint.

This is particularly so when slight arthritis is present before operation in long standing cases for it seems that the trauma of operation may aggravate it. Symptoms also persist when there is a co existing derangement such as a loose body hypertrophied synovial fringe or alar pad. An infrapatellar neuroma may give rise to hyperæsthesia and pain over the scar and may demand excision of the scar or removal of the neuroma.

Incomplete removal—the leaving behind of the posterior horn—is often associated with recurrent synovitis and a feeling of weakness in the joint which may also tend to give way. This is probably the case only when the back part of the cartilage has been loosened by the original injury or is dragged upon and partially detached by the surgeon during the operation. In either case the fault can often be diagnosed from the click on rotating the knee in full flexion.

The removal of a posterior horn may be easily accomplished through a short vertical incision behind the medial collateral ligament made with the knee in the flexed position. The sphenous vein is retracted backwards and the capsule incised. As the capsule is relaxed with the knee in flexion excellent access to the posterior horn is obtained.

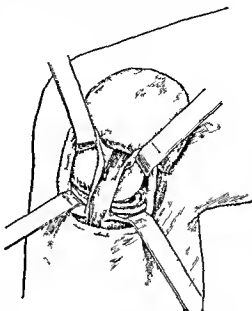


FIG. 330.—This exposure is now done through two separate incisions if there is difficulty in removing the Posterior Horn through the usual anterior incision.

CLINICAL FEATURES OF LATERAL SEMILUNAR CARTILAGE INJURIES

On account of its greater natural mobility the lateral semilunar cartilage is less frequently injured than the medial. The signs and symptoms of displacement and tears are less clearly defined than those occurring on the medial side of the joint.

The patient may complain of pain on the lateral side of the knee particularly on the lateral side of the ligamentum patellæ. He may experience a sensation of something slipping inside the knee usually on the outer side or he may volunteer the information that when he straightens the knee there is a loud crack or snap and the knee jerks into place—the so called trigger knee.

The examination is conducted on lines similar to that for the medial cartilage. There is if anything less wasting of the quadriceps the

tenderness is situated on the lateral side of the patellar ligament and in the same situation there may be a definite hollow caused by the recession of the anterior horn of the cartilage

When the knee movements are investigated the snap and jerk will often be appreciated as the leg is extended. This feature indeed is often claimed to be pathognomonic of displacement of the lateral cartilage but Jones has found it associated with the presence of a pedunculated loose body and with recurrent dislocation of the *senu membranosus tendon* over a small tibial exostosis

Discoid Lateral Cartilage

The more accurate diagnosis of lateral cartilage lesions has brought to light the frequency of an interesting congenital anomaly. Bell Jones points out that in 18 per cent of operations on the lateral cartilage the cartilage is roughly circular and thick instead of semilunar in form. The condition is frequently bilateral and is occasionally found in more than one member of a family.

A similar condition is normal in reptiles and in certain of the anthropoid apes, and Jones points out that normally in the human knee the cartilages possess a discoid or circular shape before absorption of tissue causes them to assume their semilunar shape. The condition is thus an atavism.

CLINICAL FEATURES

The most characteristic sign of a discoid cartilage is undoubtedly the loud click which is felt and heard when the knee joint is flexed or extended. This may be appreciated at any point in the arc of movement of the joint but is most common at the extremes of flexion and extension. It is actually an exaggeration of the clicking so commonly found in traumatic lesions of the normal lateral semilunar cartilage. In association with the click there is often an aching pain on the outer side of the joint and a feeling of weakness often described as a giving way of the joint. As in other varieties of lateral cartilage derangement *locking is most uncommon*.

There is sometimes a history of preceding trauma. The syndrome occurs in the young the majority of cases in the literature having occurred before the age of 18. In many the click or snap has been noticed previously but on account of the absence of symptoms has not been considered of serious import. It is often the occurrence of an injury followed by aching pain that sends the individual to the surgeon though in many cases pain and weakness come on insidiously without trauma.

PATHOLOGY

The cartilage is usually thicker than normal and is roughly quadrilateral with rounded corners. Not infrequently the peripheral margin

curves upwards to be attached to the capsule in the vicinity of the lateral femoral condyle. There is sometimes a hypertrophied pad of fat in the anterior part of the lateral compartment of the joint probably derived from the *alar fold*.

DIAGNOSIS

Pain and tenderness over the lateral cartilage with an audible and palpable snap in the absence of trauma and in a young person should suggest the presence of a congenital discoid cartilage. If the click is bilateral the suspicion is strengthened but a radiological examination is essential to exclude the presence of an exostosis which might impede the free movement of a tendon or capsular band. Finner has drawn attention to a feature in the radiographs which he considers important—the widening of the joint space between the lateral condyles of the tibia and the femur as a result of the added thickness of the cartilage.

TREATMENT OF LATERAL SEMILUNAR CARTILAGE INJURIES

The management of injuries and displacements of the lateral semilunar cartilage follows the lines already laid down for derangements of the medial cartilage. Reduction is effected by a similar manipulation and retention and preservation of muscular tone are obtained in the same manner.

Removal of the lateral cartilage is essentially similar to removal of the medial cartilage. The incisions are similar though of course on the opposite side of the joint. The access to the anterior horn is less free than on the medial side but owing to the greater mobility of the lateral cartilage the further mobilization to the attachment of the posterior horn is more simple and little difficulty should be encountered in removing the entire cartilage through the anterior incision. If however difficulty is encountered the posterior horn may be exposed through a small vertical incision behind the lateral ligament.

RECURRENCE OF SYMPTOMS

Symptoms may return or persist for reasons exactly similar to those for the medial cartilage save that there is no fear of an *infra patellar neuritis* following removal of the lateral cartilage.

A posterior horn remnant may require to be removed if so a short vertical incision is made over the joint line posterior to the lateral ligament with the joint in flexion. As the capsule is relaxed in flexion access to the posterior horn is good but care must be taken not to injure the tendon of the popliteus which is seen in the upper part of the incision though indeed division of this tendon produces no disability.

CYSTS OF THE SEMILUNAR CARTILAGES

Cystic swellings in relation to the semilunar cartilages have now been repeatedly reported, and may be regarded as fairly common.

Little is known regarding their etiology beyond the fact that they frequently appear to follow an injury and are most common in association with the lateral cartilage though the medial meniscus is also commonly affected.



FIG. 331.—Semilunar Cyst of the knee. The cyst is protruding in front of the lateral ligament.

PATHOLOGY

The cyst is of varying size, sometimes multiloculated, and is usually situated on the lateral aspect of the cartilage. Ollerenshaw, who originally drew the attention of British surgeons to this condition, has lately demonstrated a cyst attached to the inner border of the cartilage, but this is rare. In addition to the obvious marginal cysts the cartilage is often studded with many small cysts. The larger possess a fibrous tissue wall which may or may not be lined by flattened cells. The origin and nature of these cells is obscure. Ollerenshaw originally thought them endothelial in nature and still affirms this view, but other workers, notably King, believe that they are compressed synovial cells. The smaller cysts are similar in structure, and all contain a thick mucoid material resembling that found in ganglia.

ETIOLOGY

There is considerable difference of opinion concerning the origin of semilunar cysts. Allison and O'Connor attributed their development to a degenerative process resulting from interference with the blood

supply of the cartilage through trauma and in their view the mucoid material is produced by the liquefaction of dead cartilage cells. Fisher believes that the cysts are of the nature of ganglia originating between the lateral surface of the cartilage and its synovial covering. In Ollerenshaw's opinion they are developmental since they are multiple show no signs of hæmorrhage and because nests of synovial tissue which have not developed into cysts are to be found in the cartilage. King also believes that they are of the same nature as ganglia and attributes their mucoid content to a secretion by synovial like cells.

CLINICAL FEATURES

In the majority of cases the development of the cysts is traced to a fall or an injury to the affected knee and not uncommonly the trauma has occurred some years before. A swelling is usually present on the outer side of the knee it is tense and fluctuating and varying in size from a hazel nut to a small walnut. Pain is more or less continuous.

Few of the patients give the characteristic cartilage history of locking but occasionally the decided snap or jerk has been noted that indicates a lesion of the lateral cartilage.

TREATMENT

Only complete removal of the cartilage and its related cysts will effect a cure. Removal of the cyst alone is followed by recurrence.

The lateral cartilage may be removed by the method already described no attempt being made to excise the cyst intact. Alternatively a U shaped skin incision may be made and the cyst exposed by dividing the capsule overlying it. The cyst can then be removed. The cartilage is then exposed through a vertical incision between the patellar tendon and the lateral ligament. If excision of the entire cartilage is not found to be possible through an anterior capsular incision a second incision may be made behind the lateral ligament in the manner described previously.



FIG. 33°—Semilunar Cyst in connect on with the lateral cartilage

RUPTURE OF THE CRUCIATE LIGAMENTS

The powerful cruciate ligaments are injured only by severe forms of trauma

The Anterior Cruciate Ligament The anterior ligament is rendered taut when the knee is extended, and also, when the medial ligament is ruptured by internal rotation of the femur on the tibia. Injuries which are associated with exaggeration of these movements are liable to lead to rupture of the anterior cruciate, or, if the ligament withstands the strain, to avulsion of the medial tubercle of the tibial spine, near which it is attached

A diagnosis of ruptured anterior cruciate may be made with confidence if the tibia can be displaced forwards when the knee is extended. If the tibial spine has been avulsed, there is, in addition to the unnatural mobility, a definite obstruction which prevents full extension, and which feels definitely bony, in contradistinction to the locking following cartilage injuries

The Posterior Cruciate Ligament The posterior cruciate is taut in flexion. Violence which forcibly displaces the tibia backwards on the femur when the knee is flexed is therefore liable to cause rupture of the ligament. The most common cause of this injury is a fall on the flexed knee, the impact being taken on the upper end of the tibia instead of on the patella. The author saw such a case in a youth who slipped while crossing a railway line. He fell with the knee flexed, the head of the tibia striking the edge of the rail

A rupture of the posterior cruciate ligament is diagnosed by the ability to displace the tibia backwards when the knee is flexed. *Rupture of both cruciate ligaments* may accompany dislocation of the knee joint. In this event, the joint is quite flail, and the tibia can be moved both backwards and forwards.

It should be emphasized that rupture of a cruciate ligament cannot occur without damage to other joint structures, particularly the capsule of the joint, and the disability often attributed to the ruptured cruciate ligament is actually the sum total of the effects of the injury on all the damaged structures. It is for this reason that attempts to repair the cruciate ligaments are so often doomed to failure and have largely been given up

TREATMENT

When the effusion has been reduced by aspiration or by the elastic compression of a Jones' bandage the knee joint is immobilized in extension in a skin-tight plaster case. As it is desirable the patient should remain ambulatory and exercise the limb there is no reason why the foot should be included in the plaster. An Unna's paste or elastoplast bandage is applied to the limb from toes to the knee and then a skin-tight plaster applied from the adductor region to a short distance above

the malleoli over the elastoplast bandage. This allows the patient almost full use of the limb.

As soon as the joint has been immobilized the patient begins quadriceps exercises—under these circumstances consisting mainly of straight leg raising. Good development and control of the quadriceps can compensate to a considerable extent for laxity of the ligaments of the knee joint. These exercises must therefore be carried out conscientiously 5 minutes per hour throughout the waking day during the three months in which immobilization is maintained. Following removal of the plaster case active flexion is commenced and quadriceps exercises continued.

THE TREATMENT OF OLD INJURIES OF THE CRUCIATE LIGAMENTS

When the ligament has been ruptured for some time the ends become smoothed and covered over by scar tissue and no amount of immobilization will produce healing. The treatment of such a case depends on the amount and nature of the resulting disability. Some individuals will be able to get about wonderfully well without apparatus while others will be greatly helped by wearing a knee cage which limits the strain on the collateral ligaments. Some patients are so little affected that they can take an active part in games or carry out a strenuous occupation. Nevertheless in all cases the permanent abnormal mobility predisposes the joint to the later development of arthritis.

Certain operations have accordingly been devised to reconstruct or replace the injured ligaments. Technically such operations are difficult and require a high degree of skill and the results even in the most expert hands have proved unsatisfactory and the author cannot advocate their adoption.

The recovery of stability in a joint after rupture of the cruciate ligament depends chiefly on the volume and control of the extensor apparatus and upon the continuity of the medial and lateral collateral ligaments.

(a) *The Operation for Reconstruction of the Anterior Cruciate Ligament.* As the medial ligament is usually ruptured as well it also must be reconstructed. A large U shaped incision is made in front of the knee starting about the adductor tubercle and crossing in front of the tubercle of the tibia to end on the outer side at a corresponding point to the inner limb. The tubercle of the tibia is detached with the patellar tendon and these along with the patella are

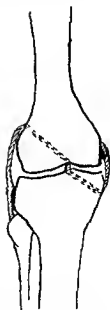


FIG. 333.—Reconstruction of the anterior cruciate ligament by Fascia Lata.

The fascial insertion below is retailed and a strip cut and threaded through the joint. Its free end is secured to the femur to strengthen the medial ligament.

reflected upwards, and the joint cavity opened. If suture of the ligament is impossible, the outer limb of the incision is continued upwards for about 10 inches, and a strip, 8 inches long and $1\frac{1}{2}$ inches wide is separated from the tibial band and reflected downwards, its lower attachment to the tibia being preserved. A tunnel is now drilled in the lateral condyle of the femur, passing downwards and inwards to the area where the cruciate ligament was attached. The inner end of the hole should be made far back so as to make the new ligament as oblique as possible in the sagittal plane. A similar tunnel is now made through the tibia, commencing at the attachment of the medial ligament and passing upwards, forwards, and laterally to finish at the site of the tibial attachment of the cruciate ligament in front of the tibial spine. Loose debris should be cleared away by a strip of gauze passed through the hole. The fascia lata is now threaded through the femoral tunnel, from the outer side, and then through the tibial tunnel, until it protrudes at the external opening in the tibia. There should be a free end left, about 3 inches in length. This is drawn tight and sutured to the most prominent point on the medial condyle, or alternatively a piece of bone is elevated from the medial condyle, the free end of the fascial ligament is laid under it, and the two secured by a staple. By attaching the fascia to the femur the medial ligament is strengthened. All the suturing should be done with the knee semi flexed, and the fascia lata fairly taut, this position should be maintained for about six weeks, until the fascia has become firmly anchored, and as this is important the limb should be encased in plaster of Paris. Great care should be taken to prevent the access of the bone dust to the joint, as it may form the nucleus of a loose body or give rise to pain at a later date. The wound is usually healed in about two weeks, thereafter the plaster is divided, the posterior half being retained for support. Massage and electricity are begun as soon as the plaster is divided, and at the end of two months the patient may be allowed to walk with the help of a knee cage.

(b) *Reconstruction of the Posterior Cruciate Ligament*. The operation is similar to that for the anterior cruciate ligament up to the exposure of the joint cavity. Thereafter the inner limb of the U shaped incision is continued up the postero medial aspect of the thigh exposing the hamstring tendons. Corresponding lengths of the semitendinosus and gracilis are now cut, the distal ends being isolated and brought down and the proximal ends sutured to the semitendinosus. A pair of artery forceps are pushed through the posterior ligament of the knee between the posterior horn of the medial meniscus and the tibia, and the two tendons pulled through the posterior ligament until their free ends hang out from the front of the joint. A hole is now bored through the medial condyle of the femur, the internal opening being as far forwards as possible on the intercondylar notch, and the outer above the middle of the lateral aspect of the condyle immediately above the joint. The tendons are now

pulled through this hole and with the knee extended tightened up and attached by their free ends to the medial condyle of the tibia. By attaching the tendons to the tibia any weakness of the medial ligament is compensated for. The joint is immobilized in the extended position for six weeks and thereafter a light plaster is fitted and the patient allowed to walk. A moulded knee cap is used for about six months.

RUPTURE OF THE LATERAL LIGAMENTS

Trauma to the medial and lateral collateral ligaments of the knee joint takes place as the result of abducting and adducting injuries with the knee joint in extension while the extensor apparatus is caught off guard. The medial ligament is the more important of the two and is the more frequently injured. The diagnosis is made on the history of the injury, the position of the tenderness which is in the line of the ligaments, the ability to open up the knee joint on the side injured and on the absence of signs suggestive of meniscus damage. An X ray shows no abnormality.

TREATMENT

The treatment of the acute lesion is essentially the same as that described under Treatment of Rupture of the Cruciate Ligaments. The joint is immobilized and compressed by a Jones bandage until the effusion has subsided. An Unna's paste support is applied from the root of the toes to the knee joint and a skin tight plaster applied from the adductor region overlapping the Unna's paste and terminating some little distance above the malleoli. When the plaster case has been applied the patient becomes ambulatory and practices quadriceps exercises continuously throughout the three months in which the plaster case is retained. Good results may be expected in acute injuries if quadriceps exercises are carried out conscientiously.

It has been stated previously that rupture of the medial collateral ligament may be accompanied by injury to the adjacent meniscus. It is often impossible to diagnose injury to the cartilage during the acute phase but it may become clear during the period of rehabilitation that some additional internal derangement is present. This possibility should be kept in mind when late symptoms arise.

OLD INJURIES OF THE MEDIAL COLLATERAL LIGAMENT

Unrecognized or untreated cases of injury to the medial collateral ligament frequently result in symptoms due to instability of the joint. The possibility of a co-existing tear of the medial meniscus should be considered.

These cases always exhibit a gross degree of quadriceps insufficiency and before operative treatment is considered a course of vigorous quadriceps exercises should be prescribed and the case reassessed at

the end of three months. Many operative procedures have been recommended for old injuries of the medial ligament. Most operations aim at the strengthening or reinforcing of a weak ligament by plication strips of fascia lata or by means of tendons. In spite of the ingenuity of some of these procedures the results in most cases have proved unsatisfactory.

Operative Treatment. Muck has pointed out that instability of the knee in these cases is due to laxity of the medial ligament rather than to weakness of the structure. He considers that in most cases the weakness exists so that part of the ligament adjacent to the tibial head—the portion which has healed by fibrous tissue. He concluded that if the integrity of these structures could be restored the instability would be relieved and good function obtained. The aim of the operation which he suggests is to shorten the relaxed ligament and to eliminate the weakened part which is made up of scar tissue.

The knee joint and upper end of the tibia are exposed by an incision from the adductor tubercle to a point 4 inches below the articular surface of the tibia. The area of bone including the attachment of the medial collateral ligament is removed from the head of the tibia and the ligament shortened by mortising the bone flap into the tibia at a lower level. The medial meniscus is removed. The ligament is thus shortened and that part of the ligament formed by scar tissue brought against the denuded bone of the tibial head.

FRACTURES OF THE TIBIAL SPINE

Lesions of the tibial spine are not uncommon and are often associated with injury to one or other of the cruciate ligaments, particularly the anterior. Smith and Jones recognize three groups of injuries.

1 Avulsion of the Spine or of its Medial Tubercle. This is produced by a similar mechanism to rupture of the anterior cruciate. Usually the ligament has remained intact, leaving the bony process to bear the brunt of the strain. The fragment is usually displaced anteriorly.

2 Fracture of the Lateral Tubercle. The fracture in this case is usually due to direct contact with the inner margin of the lateral femoral condyle and the fragment is pulled a little to the medial side. The mechanism of the injury therefore is like that which results in lesions of the medial semilunar cartilage—extreme rotatory violence.

3 Fracture of the Spine in Association with Fractures of the Tibial Condyles. Here the fracture is a crush fracture, the result of severe trauma and in addition to the violent contact between the opposing articular surfaces there is usually some forcible abduction or adduction strain leading to fracture of the medial or lateral condyles respectively. It may thus result from falls from a height or from a heavy weight striking the thigh or knee when the joint is flexed.

CLINICAL FEATURES

The clinical evidences of spinal fractures are often masked by those of coincident lesions of the semilunar cartilage the collateral ligaments or the cruciates. In the first two types there is a definite bony block which prohibits full extension. In neglected cases this persists and is associated with recurrent synovitis. In the crush fracture type the co-existing condylar fracture usually causes marked and obvious lateral deformity.

TREATMENT

When the effusion or hæmarthrosis has been reduced by aspiration or by the elastic pressure of a Jones bandage a skin tight plaster of the same type as that described under Treatment of Ruptures of the Cruciate Ligament is applied and worn for a period of three months during which time the patient concentrates on exercises designed to increase the volume and tone of the extensor apparatus.

In some cases however the bony block to extension persists giving rise to functional disability and under these circumstances the fragment should be removed or replaced by operation.

The knee joint is laid open by Timbrell Fisher's patella displacing method. It is usually necessary to gouge out a small flake of bone under the fractured spine to allow its replacement. If the obstructing fragment is large it may be excised but if the cruciate ligament is attached to it it is better to replace it and allow it to heal as an ordinary fracture. It is usually necessary to prepare a bed for it with a gouge before it can be accurately reduced.

AFFECTIONS OF THE INFRA PATELLAR PAD

When the knee joint is extended the patella is drawn up by the contracting quadriceps and the infra patellar pad of fat is similarly pulled up to avoid its being caught between the tibia and the femur. When an excess of fat has been deposited in the pad however or when the quadriceps has lost its tone the pad may not be sufficiently drawn up and is then liable to be nipped between the opposing articular surfaces. Repeated trauma of this nature is associated with hæmorrhage into the pad and further thickening it becomes hard and may project beyond the margins of the patellar ligament in the form of two small swellings about the size of a walnut. This traumatic form of enlargement is most common in young athletes.

In older subjects the infra patellar pad may be hypertrophied in association with intra articular arthritic changes as for example villous hypertrophy of the synovial membrane.

SYMPTOMATOLOGY

The clinical features of an affection of the infra patellar pad while not so distinctive as those of a lesion of a meniscus are yet in some

respects characteristic. The knee is painful, but the pain, which is constantly situated immediately behind the infra patellar ligament, occurs only when the knee is used. The joint tends also to be stiff, and the patient may complain that it is weak and liable to recurrent attacks of swelling (effusion). From the interposition of the hypertrophied fat between the articular surfaces there results a progressive limitation of extension which makes the patient walk with his knee partly flexed, bearing his weight on the metatarso phalangeal joints with the foot in the equinus position.

True locking does not occur, but at intervals the joint may appear to "give way" or a sharp stabbing pain may occur which temporarily arrests the patient's activity.

The pad, on examination, is usually enlarged, and the swellings on either side of the ligamentum patellæ are tender. This tenderness persists or rather is more pronounced when the joint is fully extended, and thus provides a characteristic sign. The quadriceps constantly shows a degree of atrophy.

Radiological examination is usually negative, occasionally, however, calcium salts are deposited in the hypertrophied fat and may give a shadow in the situation of the pad.

TREATMENT

(a) **Conservative** The symptoms are produced mainly when the knee is extended, so that conservative measures should seek to limit this movement. Jones recommends the simple but effective device of raising the heel of the boot on the affected side, this prevents full extension, and may be followed by subsidence of the swelling and disappearance of the symptoms. In severer cases, further measures may be required, in this connection, a hinged knee cage, so arranged that extension is arrested some 20° – 30° short of full extension, may prove of great service.

Conservative measures should always be supplemented by exercises, massage, and faradism, to strengthen the wasted quadriceps.

(b) **Operative** If conservative methods prove ineffective, the pad should be removed.

An incision is made to the medial side of the lower part of the patella, the pad is found to be loosely attached to the posterior surface of the patellar tendon, about the upper end of the tibia, but firmly fixed to the articular capsule. The three prolongations at its upper end are severed by a pair of curved scissors as near its insertion into the meniscus as possible. This procedure may open the knee joint, but no attempt is made to close it. After closure of the aponeurosis and skin the knee joint is immobilized for eight days, and at the end of that time active movements are begun. Complete recovery usually results in from two to three months. In many cases more adequate exposure is needed and Tumbrell Fisher's patella displacing method should be employed.

BIPARTITE PATELLA

The patella like other sesamoid bones is subject to many anomalies of development which though they have little or no clinical significance are of great diagnostic importance

The patella arises usually from a single centre of ossification, though occasionally two or even more centres are present. These several centres almost invariably fuse to form a single bone but occasionally they remain discrete giving the condition of bipartite or even multipartite patella. The importance of the condition lies in the fact that the unwary may confuse its radiographic appearance with that of fracture particularly since it is usually first observed when the knee is X rayed following an injury.

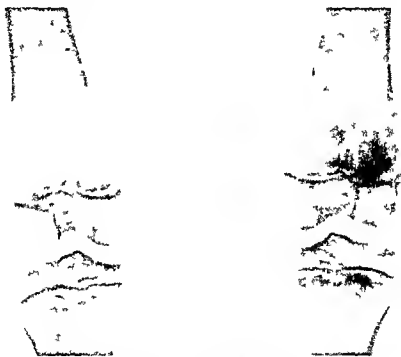


FIG. 334.—Congenital Bilateral Bipartite Patellae

Radiological Appearance The general contour of the patella is not grossly altered but the bone is seen to consist of a larger and one or two smaller fragments the latter situated usually at the upper and outer quadrant. The structure of the smaller fragments is similar to that of the main part of the bone consisting of a shell of cortical bone, surrounding normal cancellous tissue. The fragment has a semilunar outer margin but the border adjacent to the larger fragment is linear and appears in the anteroposterior view as a straight line. There is usually a definite radiological interval between the two fragments, but in the dissected specimen this apparent gap is occupied by cartilage.

In five out of six cases the condition is bilateral, while a similar condition is not uncommonly observed in the sesamoid bone beneath the head of the first metatarsal

DIAGNOSIS

The condition has to be distinguished from fractures of the patella. These, however, are accompanied by a definite history of injury, and the usual clinical manifestations of trauma are present. The important points in the differential radiological diagnosis are

1 The margins of the fragments of bipartite patella are smooth and consist of cortical bone. Fractured fragments show more or less serrated edges and involve cancellous bone.

2 The position of the intervening gap is also significant. Fractures rarely occur in the upper and outer quadrant, but this is almost invariably the site of the congenital anomaly.

3 The congenital error is frequently bilateral.

HABITUAL OR RECURRENT DISLOCATION OF THE PATELLA

The patella may be displaced as a result of injury, or congenital abnormality, the dislocation may be upward, lateral, or medial, though clinically all others save the lateral displacement may be considered unusual.

Medial dislocation usually results from injury, but may occur in severe cases of genu varum.



FIG. 335.—Recurrent Lateral Dislocation of the Patella.

The lateral deviation of the patellar tendon is evident.

Occasionally as a result of injury the bone may rotate on its long axis so that one of its borders engages between the condyles of the femur. This is a rare form of dislocation. The upward dislocation is also traumatic in origin, for there has usually been a neglected rupture of the ligamentum patellae.

The commoner lateral dislocation is the most important and also the type most liable to become habitual or recurrent, indeed, it is the lesion usually implied by the term recurrent dislocation or slipping patella.

Jones and Lovett describe three types.

(1) *The Congenital type*, usually accompanied by other abnormalities and in particular associated with poor development of the lateral femoral condyle. Complete reduction of the dislocated patella is usually impossible in this type.

(ii) *Rachitic type* Lateral displacement of the patella may be associated with rachitic genu valgum. As the knock knee is flexed, the bone slips over the condyle but at first complete restitution occurs when the leg is extended again. Later secondary changes may render the dislocation permanent.

(iii) *The Traumatic Type* This type usually occurs in females, often in adolescence and it is often associated with a varying degree of genu valgum or with an extra long ligamentum patellæ. Occasionally,



FIG. 336.—Congenital Dislocation of the Patella

Radiograph showing in this case a degree of genu valgum and a small lateral femoral condyle

too the whole joint is of the loose relaxed type, and sometimes the lateral condyle is small. These conditions predispose to the occurrence of the dislocation, since they all favour the outward pull of the quadriceps. (Goldthwaite)

The usual injury is a blow or kick, but not uncommonly the displacement is the result of muscular action.

CLINICAL FEATURES OF RECURRENT DISLOCATION

Each recurrence is usually precipitated by a sudden contraction of the quadriceps when the knee is extended or semi flexed and the foot and leg everted, so that the insertion of the ligamentum patellæ

comes to lie more laterally, and the quadriceps is allowed to drag with increased force on the already unstable bone

At the time of the attack, the patient usually falls to the ground

When the displacement is of frequent occurrence, little or no pain is experienced but when long intervals elapse between the attacks the accident is associated with considerable pain disability, and swelling of the joint

Reduction is generally easy The knee is first fully extended, and then the thigh flexed to relax the quadriceps, the knee cap is then

manipulated into position by pushing it medially, at the same time correcting any rotation The more frequent the displacement, the easier the reduction becomes, ultimately, indeed, the patient may learn to correct the dislocation himself In time however, the repeated recurrences result in a relaxed weakened, and unstable joint

TREATMENT

Occasionally, recurrence may be prevented by the use of a firm bandage or knee cap, though as the condition is extremely disabling and annoying more radical measures are usually demanded In addition to mechanical measures a number of operations have been suggested and performed

Conservative Treatment

This is of value only before the displacement has become

habitual The inner side of the heel is raised and a knee cage worn to prevent lateral deviation during walking The patient is also instructed to walk with the toes turned and the quadriceps and in particular the fibres of the vastus medialis are developed to their fullest extent

Operative Treatment

There is a wide choice of operations, and the final decision between them depends on the cause of the error When there is no or only slight, genu valgum present an operation on the soft tissues is usually sufficient

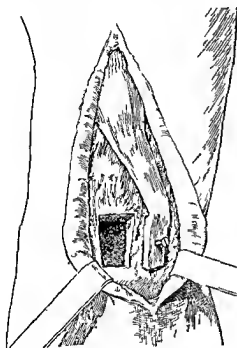


FIG 337—Recurrent Dislocation of the Patella

Operation of transplantation of the patellar tendon with the femoral tubercle

(a) **Soft Tissue Operations.** (1) **Goldthwaite's Operation.** A curved incision is made from below and to the outer side of the tibial tubercle inwards and curving upwards towards the inner margin of the patella. The patellar tendon is exposed and split longitudinally into two equal halves. The lateral half is erased from its insertion, passed under the inner half and attached to the periosteum of the tibia and the expansion of the sartorius muscle into the antero medial aspect of that bone. The transposed ligament can, if necessary, be shortened, to increase the pull. The knee is fixed for six weeks in a plaster-of Paris case.

(2) **Gallie's Operation.** Gallie suggested the use of a living suture of fascia lata to form a ligament between the patella and the medial femoral condyle, and so to anchor the patella. Soutter has pointed out that whereas the relationship of the patella to the femur is constantly changing, thus throwing a great deal of strain on the fascial ligament, the relationship of the patella to the tibia is constant, and he has modified Gallie's original method by anchoring the patella to that bone.

A straight incision is made downwards and slightly inwards from the proximal edge of the patella to the medial condyle of the tibia, the two bones are thus exposed, and a drill hole bored in each. A thin strip of fascia lata, from the outer side of the thigh, is then threaded through the two drill holes, its free ends being thereafter joined. The joint should be immobilized for six weeks afterwards.

(3) **Tendon Transplantation.** The tendon of the gracilis or of the semi tendinosus may be divided at its insertion, and transplanted into the inner border of the patella.

(4) **Krogius's Operation.** A Kocher's J shaped incision is made from slightly above the patella to the insertion of the ligamentum patellæ, exposing the ilio tibial tract, the tendinous expansion of the vastus lateralis, and the fibrous capsule. These tissues, lying as they do on the lateral side of the joint, are tense, and, when longitudinally incised, the edges of the incision separate considerably. On the medial side of the patella, two parallel incisions are made longitudinally through the capsule, and the narrow strip of tissue thus marked out separated from its bed. It is left attached, above to the muscles and fascia of the medial side of the thigh, and below to the tendinous expansion of the vastus medialis, it thus forms a kind of "bridge" or "pier" graft. The strip of tissue is transposed across the patella to the lateral side of the joint, and now occupies the gap between the edges of the lateral capsular incision. The edges of the graft are then sutured to the two edges of the lateral wound. The tense lateral portion of the capsule, which tended to draw the patella outwards, has thus been divided, and a portion taken from the relaxed medial portion to fill the gap produced between the edges by the relief of tension.

(b) **Bone Operations.** (1) **Osteotomy.** If knock-knee is the cause of the habitual dislocation, the obvious line of treatment is to

correct the deformity and so alter the direction of the pull of the quadriceps. Genu valgum should be treated by supracondylar osteotomy, carried out through a small incision on the medial side of the knee immediately above the adductor tubercle. After the bone has been fractured the lower fragment should be slightly rotated medially to bring the lateral condyle further forward, while a certain degree of bow leg can with advantage be aimed at since it increases the probability of improvement. The after care is simply that of an osteotomy or fracture plaster for six or seven weeks, and thereafter a walking caliper for four or five months.

(2) **Albee's Operation** A semi lunar skin incision reaching from above the lateral condyle to below the tibial tubercle is made round the lateral margin of the patella. The condyle is exposed and a longitudinal incision 2 inches long made about $\frac{1}{2}$ inch behind the anterior articular surface with a broad osteotome. The fragment of bone thus

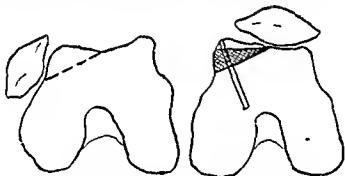


FIG. 338.—Recurrent Lateral Dislocation of the Patella

Albee's method of treatment by insertion of bone graft under the raised lateral condyle of the femur

marked out is elevated or eased up slightly out of its bed, i.e. a green stick fracture is produced through the intercondylar groove. A wedge shaped piece of bone removed from the crest of the tibia is then inserted into the gap between the separated fragment and the remainder of the condyle. If necessary, the graft and the slip of bone it supports may be secured in place by a bone pin driven through them and into the condyle but usually the soft tissues hold them as firmly as is necessary. The skin wound is closed by continuous sutures of plain catgut, and a plaster of Paris case applied and kept on for three weeks. At the end of this time massage and passive movements may be begun.

(3) **Transplantation of the Tubercle of the Tibia** An incision is made vertically downwards from the lateral border of the patella to the outer side of the tubercle of the tibia from which point it deviates medially to end over the inner aspect of the tibia. The ligamentum patellæ is then defined, and, along with the small block of bone to which it is attached it is separated from the tibia. A gap or bed is now made on the antero medial aspect of the upper end of

the tibia its shape corresponding to that of the bony block at the end of the ligament. The block is now inserted into its new bed and secured in place by a bone peg or screw nail.

The operation may with advantage in certain cases be supplemented with a soft tissue operation such as that of Krogius.

Choice of Operation. The author has on occasion used most of these operations but unless some definite contra-indication exists he now practises the complete transplantation of the infra patellar ligament and its attached segment of bone to the medial side of the tibia. He has found this operation entirely satisfactory. If the contracture of the tissues on the lateral side of the patella is marked he performs in addition a capsulotomy after the manner of Krogius. If there is marked genu valgum a corrective osteotomy is of course carried out.

LOOSE BODIES

The occurrence in joints of a variety of types of loose body has long been recognized. Practically every joint in the body has been reported on as containing such bodies but they are most frequently found in the knee joint. An opportunity is taken here therefore of reviewing the whole subject.

Timbrell Fisher has done much to clarify our understanding of the pathology and the etiology of loose bodies and his classification has found almost universal acceptance. In some respects it is confusing however and the author has now adopted the following grouping.

A Classification of Loose Bodies

A Fibrinous Loose Bodies (structureless bodies composed of fibrinous material or of necrotic synovial membrane)

- | | |
|---------------------|----------------------|
| <i>Traumatic</i> | 1 After hæmorrhage |
| <i>Pathological</i> | In association with— |
| | 1 Tuberculosis |
| | 2 Chronic synovitis |

B Fibrous Loose Bodies (composed of fibrous tissue)

- | | |
|---------------------|--|
| <i>Traumatic</i> | 1 Organization of hæmorrhage into villus |
| <i>Pathological</i> | In association with— |
| | 1 Tuberculosis (nodular tuberculosis) |
| | 2 Syphilis (gummata) |
| | 3 Osteo arthritis |

C Cartilaginous Loose Bodies (composed entirely of cartilage cells)

- | | |
|------------------|--|
| <i>Traumatic</i> | Separation of whole or part of an intra articular fibro cartilage, e.g. meniscus |
|------------------|--|

D Osteo Cartilaginous Loose Bodies

- | | |
|---------------------|--|
| <i>Traumatic</i> | 1 Displacement of non articulating epiphysis |
| <i>Pathological</i> | 1 Detachment of portion of articular surface (osteochondritis dissecans) |
| | 2 Detachment of osteophytes in— <i>Tabes dorsalis</i> <i>Osteo arthritis</i> |
| | 3 Separation of sequestra in— <i>Tuberculosis</i> <i>Acute arthritis</i> |
| | 4 Synovial Chondromata |

E Miscellaneous Loose Bodies

- 1 Introduced Foreign Bodies
- 2 Lipoma
- 3 Angioma
- 4 Secondary Carcinoma etc etc

The above table includes the whole range of loose bodies but it should be understood that the majority of these are of very rare occurrence and for practical purposes the pathological diagnosis rests between osteo arthritic loose bodies synovial chondromata osteochondritis dissecans and displaced epiphyses. Some of the above conditions may now be considered in greater detail.

A Fibrinous Loose Bodies, or Necrotic Synovium

The typical fibrinous loose bodies arise usually after a traumatic intra articular hæmorrhage and are often laminated. Large numbers are present.

The pathological type—composed of necrotic synovial tissue—are usually associated with chronic synovitis or arthritis especially of tuberculous origin. They are multiple and constitute the melon seed bodies so distinctive of certain of the more chronic forms of tuberculous arthritis.

B Fibrous Loose Bodies

These may be attached to the synovial membrane or free in the joint cavity.

The traumatic type arises at the site of an injury to the synovial membrane. There is usually a breach of surface and as a result of the irritation caused by the constant movement of the joint a condition of chronic inflammation is set up. In consequence a pedunculated tag is formed which sooner or later separates into the joint.

The pathological type occurs in association principally with tuberculosis and osteo arthritis—both diseases in which villous overgrowth of the synovial membrane is common. The hypertrophied villi project more and more into the joint in some cases the base becomes

attenuated to form a pedicle and ultimately the villus may drop off actually into the joint cavity. All stages of detachment may be observed in the same joint.

Gummita of joints are not common.

C Cartilaginous Loose Bodies

Loose bodies composed entirely of cartilage are rare and are derived from one or other of the semilunars usually the medial. They originate from partial or complete detachment of the cartilage in whole or in part. Jones and Lovett report a case where a rounded mass the size of a large bean was the only trace of a vanished medial semilunar. The connection between the mass and the missing cartilage was assumed since the body had retained a fibrous attachment corresponding to that of the semilunar.

D Osteo Cartilaginous Loose Bodies

Traumatic Type

(a) **Displaced Non articulating Epiphyses** This type is found in its most classical form in the elbow joint where as a result of certain forms of trauma the medial epicondyle is forcibly displaced into the joint cavity. The displaced fragment frequently goes unrecognized and attention may be drawn to it only by the persistent limitation of joint movement and by the occurrence of signs and symptoms indicating a lesion of the ulnar nerve. Platt has drawn attention to the frequent occurrence of nerve phenomena in association with the injury and the importance of its early recognition is thus increased.

At the time of injury the joint is usually so swollen that deformity is not apparent but a point of extreme tenderness is found over the situation of the epicondyle.

In late cases when the radiographic examination may suggest the presence of a loose body the possibility of this lesion may be suggested by the increase of the carrying angle (cubitus valgus) which almost inevitably results.

TREATMENT

In immediate cases after the swelling has subsided a little the joint is opened the detached fragment replaced in position and secured there by a small peg or nail.

In late cases when the fragment constitutes a free joint body it should be removed.

Some observers consider that the frequency of late ulnar neuritis as a sequel of this injury justifies the performance of anterior transposition of the ulnar nerve at the same time as the fragment is replaced or excised.

(b) **Detached Portions of Articular Surface—Osteochondritis Dissecans** Osteochondritis dissecans is a condition in which a fragment of articular cartilage with or without subchondral bone becomes

either partially or completely separated at characteristic sites on the articular surfaces of certain joints

The joint most commonly affected is the knee but similar lesions have been found in the elbow ankle and hip and even in the heel of a metatarsal In some cases the condition is bilateral

The typical sites in the various joints are as follows in the knee the medial condyle close to the intercondylar notch in the elbow the capitellum in the ankle the trochlear surface of the astragalus and in the hip the superior aspect of the head of the femur

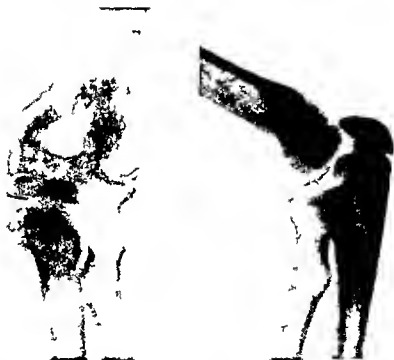


FIG. 339.—Detached fragment of the medial epicondyle of the humerus.

The medial epicondyle of the humerus has been fractured and displaced into the joint. The fragment is shown in the position it occupies in the joint.

ETIOLOGY

The actual mechanism of the detachment of portions of the articular surface is a much debated problem. Originally it was believed that following trauma there developed a pathological process—quiet necrosis—which led to the gradual extrusion of a part of the traumatized surface. This was the view of Paget and of König but both these observers agreed that by the time the body separated all signs of the underlying pathological process had disappeared. It was this conception of the process that led König to name it osteochondritis dissecans a name that has remained firmly entrenched in the literature although its aptitude is by no means certain.

Since the original observations many alternative explanations have been proposed. In the main they may be grouped into those that attribute it to trauma and those which postulate some primary disturbance of the articular surface.

The traumatic theory has been especially championed by Timbrell, Fisher, and lately by Fairbank. Among the possible sequelæ of trauma are included subchondral fracture with gradual separation of a fragment, damage to the vessels supplying a portion of the articular surface and a post-traumatic inflammatory condition.



Fig. 340—Osteochondritis Dissecans

The loose body is seen in the joint space and its source on the articular aspect of the medial condyle.

The view that the fragment is detached after a localized fracture is at first sight supported by the fact that trauma in many cases is a feature of the history. The situations of the lesion, however, are not those in which the manifestations of trauma would be expected. Large numbers of experiments have been directed to surmount this difficulty, and in some cases a plausible hypothesis has been suggested. Thus in the case of the knee it is alleged that the trauma is produced by one of the other bones of the joint, the patella or the tibial spine. The best case has been made out for the latter. The medial tubercle is always longer than the lateral and it has been pointed out that in osteochondritis dissecans it appears hypertrophied. It is

suggested that forced rotation of the tibia on the femur or the femur on the tibia or forcible medial displacement of the tibia on the femur will cause the spine to impinge on the articular surface of the medial condyle. In the case of the hip the lesion occurs on the superior surface of the head where it might conceivably be produced by forcible contact with the acetabular roof.



FIG. 341.—Loose Bodies in the Knee Joint.
There is evidence of the presence of a loose body on the articular surface of the femur.

Fairbank supports the view that the lesion is a fracture. He bases this conclusion on the following facts:

- 1 It occurs most frequently in adolescents and young adults indulging in vigorous pastimes.
- 2 Typical lesions are seen in radiographs and revealed by operation after definite and sometimes recent trauma.
- 3 A lesion at the typical site may involve the cartilage only; the detached fragment consisting of normal articular cartilage. In such cases there is a definite history of trauma.
- 4 There is entire absence of inflammatory changes in and about the lesions.
- 5 The gross appearance when operation is performed early suggests nothing but a simple recent fracture. When sufficient time has elapsed for changes to occur the only ones that do take place are

only those which would be expected from an effort on the part of the tissues to repair the damage. Exactly similar changes are occasionally found on the more exposed parts of the femoral articular surface where the traumatic origin of the lesions is never disputed.

6 When the detached fragment is suspended by a vascular pedicle the bone in it is not dead and is not a sequestrum.



FIG. 342.—Osteochondritis Dissecans of the Talus following an Adduction Fracture of the Ankle.

7 To explain the occurrence of the lesion in both knees or in the knees of more than one member of a family it is easier to assume the presence of anatomical peculiarities favouring exceptional local trauma than the occurrence of embolism damage to the blood supply or any other change.

Despite such distinguished support it would appear that the lesion if due to trauma would be more common and more frequent in joints other than the knee where injury occurs as often. Further its occurrence or rather its discovery after injury is no proof of its dependence on injury since in some cases at least a traumatic history is not forthcoming.

The theory that the separation of the fragment is due to injury to the vessels supplying the articular surface does not bear scrutiny. The subchondral bone is supplied by a veritable lake of blood in the

shape of numerous capillaries. The articular cartilage derives its nutrition from the synovial fluid and in some cases the body is entirely cartilaginous the underlying bone being normal. Further as Phemister has shown interference with the vessels supplying an area of bone results in aseptic necrosis not sequestration of a living fragment.

The alternative view—that there is a pre-existing change in the articular cartilage or the subchondral bone—was originally proposed by Axhausen who attributed the change to mildly infective embolism of a small endartery supplying the affected area. Other similar views have blamed aseptic thrombosis of an endartery and endarteritis obliterans.

It has also been suggested that there is an underlying osteoarthritic basis though the age period renders this unlikely. Bruce drew an analogy between osteochondritis dissecans and the lesion at the metatarsal head generally known as Kohler's disease. He demonstrated that the deformation of the articular surface is preceded by the appearance of a definite zone of bone absorption and that the indentation of the surface is sometimes followed by the formation of a loose body in the joint and he suggested that a similar process might account for the lesion of osteochondritis dissecans. It is extremely doubtful whether the conditions are in any way comparable and for the moment the mechanism of loose body formation in osteochondritis dissecans remains a mystery.

PATHOLOGY

The body may be lying quite free in the joint cavity or attached to the articular surface by a fibrous band or by a hinge of articular cartilage. In the knee it is generally derived from the medial condyle.

The appearance of the body varies greatly. It is generally oval in shape and with a plane and convex surface. The convex surface is often rough and may consist of cancellous bone but when the body has existed in the joint for a long time it changes its character. The rough surface becomes smoothed out and rounded and the cartilage may proliferate until the body acquires considerable proportions. The over-exuberant production of new cartilage cells may lead to the formation of a veritable cartilaginous tumour.

SYMPTOMS

From the standpoint of the clinical history cases may be placed in three fairly well-defined groups. In *one group* are those cases where the knee is painful, swollen and tender and locked in from 15 to 45 degrees of flexion. The appearance is suggestive of injury and the condition has often begun suddenly subsequent to a twist or other minor injury. There is usually no history of previous disability. X-ray examination reveals an osteochondritic focus on the medial femoral condyle with one or it may be two loose bodies in the joint. The *second group* includes cases which are almost asymptomatic. It occasionally happens that an X-ray of a supposedly normal knee taken for comparison reveals a definite osteochondritic focus without free

the joint the body lying quietly in its bed on the medial condyle. In other cases even though the fragment is not large, the symptoms may be those of a mild chronic joint disturbance such as vague discomfort with persistent or recurrent effusion aggravated by violent exertion, weakness and loss of confidence in the joint. The largest of cases fall into the third class in which there is a definite history of trauma and of a chronic troublesome knee joint for two or three years. The complaint is a feeling of soreness or definite pain on weight bearing associated with swelling. The joint tends to become stiff and stiffness is common. The symptoms are sometimes intermittent but more often intercurrent and are often associated with lockings of the joint on rising from the sitting or squatting position. Some patients occasionally have a loose body in the joint.



FIG 343—Multiple Loose Bodies in the Knee Joint

TREATMENT

Ellstrom advises operation in the absence of symptoms. He believes that if such treatment is not given osteoarthritis will develop. In Fairbank's opinion this late complication cannot be prevented even by early operation. In the presence of symptoms the joint should always be explored when the joint is opened the articular surface is found to be uneven but the site of the lesion is clearly indicated by a change in colour or texture of the overlying cartilage or the extent of the lesion is indicated by a groove. An attempt should be made to determine whether the circumscribed area of cartilage is movable or not. If it is movable it should be excised together with any loose bone beneath it but if it is not movable the problem is more difficult and the excision of the cartilage within the circumference of the lesion should be the determining factor. If the cartilage is definitely soft spongy and rough it should be excised even if it is unbroken all loose bone should be removed and the edges of the hole should be carefully smoothed. If the cartilage is almost normal in appearance and the lesion is only just discernible and if there is nothing to suggest that a fragment of the bone is loose the lesion may safely be left alone. When there is any doubt regarding the condition and particularly when the mobility of the fragment beneath is uncertain it is wiser to excise the lesion.

When the lesion presents the more usual appearance of the cartilage fractured but with an unbroken portion holding the fragment more or less in position the separation should be completed and the fragment removed. The cartilaginous margins of the crater should be carefully bevelled when necessary, and any undermined portions removed. If the fragment is free in the joint and the radiographs show the site from which it came, the incision should be planned to allow inspection of the crater as well as removal of the loose body. In all cases the condition of the semilunar cartilage should be determined.

The immediate prognosis and the prognosis for some years to come are undoubtedly good but the remote prognosis is less favourable as there is reason to believe that osteo arthritic changes are likely to occur sooner or later.

Pathological Osteo Cartilaginous Bodies

1 **Detached Osteophytes in (a) Osteo-arthritis** In osteo-arthritis, three forms of loose body may occur—synovial chondroma (see p 735), detached marginal osteophyte, and detached "epi articular ecchondrosis" or central osteophyte.

The marginal osteophytes are, in certain situations, prone to injury, and may be completely broken off, or fractured though if the fracture is incomplete, the osteophyte may remain attached by a narrow pedicle. Immediately after the injury the raw bony surface can be easily recognized, but it is soon covered over by proliferating cartilage.

Such bodies are usually pear shaped. On section, the peripheral area is found to consist of well-developed fibro cartilage, and the central portion of dead bone with a well defined cancellous arrangement.

Rarely there may be more than one detached osteophyte, and frequently in the same joint there are other forms of osteo arthritic loose body, e.g. synovial chondromata.

The occurrence, in osteo arthritic joints of localized areas of hyperplasia of the articular cartilage was first demonstrated by Shattock. These "epi articular ecchondroses" are essentially similar in nature to the osteophytic outgrowths at the articular margin, and the central portion is likewise often ossified. Like the marginal outgrowth, these central osteophytes may become broken off and form loose bodies.

(b) *Tabes Dorsalis* In the hypertrophic form of Charcot's disease, osteophytic formation may also give rise to loose bodies, similar to the osteophytes of osteo arthritis, but, owing to the more extreme nature of the pathological process in tabes commonly larger.

2. For the sake of completeness, two types of loose body may be included—the tuberculous and the acute inflammatory.

(a) **Tuberculous Sequestra** Necrosis of large areas of bone is relatively uncommon in tuberculosis but it may occur, especially in the articular surface of the femur, when the sequestrum is extruded into the joint cavity. It is commonly wedge shaped, and the actual

separation is slow which supports the explanation that the occurrence is the result of interference with the blood supply

(b) **Acute Inflammatory Sequestra** In acute arthritis in children whole or part of the epiphysis may be detached and be free in the joint As a loose body the occurrence is of no significance since the major condition overshadows everything else

3 Synovial Chondroma Kolliker was the first to describe the occurrence of cartilage cells in the villi of the synovial membrane At that time it was thought that these cells could be present without the membrane being accounted abnormal but the consensus of modern opinion is against this Most observers agree however that under the influence of certain abnormal stimuli connective tissue cells can become transformed into any of the specialized mesodermal tissues of the body such as bone or cartilage

If we accept the hypothesis that synovial fringes may undergo cartilaginous transformation the origin of synovial chondromata can be readily appreciated for the cartilage cells of the villus may take on true tumour growth with the formation of chondromata which later become detached into the joint cavity While in the majority of cases the tumours are entirely composed of cartilage there is no question that certain of them contain a nucleus of true bone Since metaplasia of synovial tissue into cartilage is known to occur there is no reason why a similar metaplasia to bone may not take place with equal readiness Greig insists however that when bone is found in the centre of a loose body it must have been formed before the body became detached from its parent membrane because the formation of bone demands a lavish blood supply which is not available after the body has become free For those which contain a bony nucleus the term *osteo chondroma* would be more accurate

Once detached the tumour may increase in size but this increase is entirely cartilaginous for cartilage is a structure of low metabolism and can derive from the articular effusion sufficient nourishment to enable its cells both to live and proliferate (Greig)

PATHOLOGY

Such chondromata may be single are frequently multiple and occasionally diffuse

The *single chondroma* may be lying free in the joint cavity or attached to the synovial membrane by a definite pedicle It is an oval body composed almost entirely of cartilage cells occasionally the centre of the tumour is occupied by a loculated cavity the result of mucinoid degeneration (Fisher)

Occasionally the body shows obvious lamination and Fisher has suggested that this is due to the deposition in layers of calcium salts derived from the synovial fluid which has permeated the body Certain of the tumours too are definite *osteo chondromata* containing a nucleus of bone

The *multiple chondromata* are smaller than the single variety and may be present in enormous numbers. Berry has recorded a case in which no fewer than 1047 such cartilaginous bodies were found in the knee joint of a woman 22 years of age.

The size and shape of the individual tumours vary. Groups of them may occupy pouches and recesses of the synovial membrane and they may be flattened from mutual compression. Usually there is a combination of pedunculated and free tumours and their general character is similar to that of the single variety save for the points discussed above.



FIG. 344.—Loose Body in the Knee Joint.

Diffuse chondromata (synovial chondromatosis) is a remarkable condition in which the whole synovial membrane is studded with discrete nodules of cartilage which undergo ossification and nearly all of which have a nucleus of true bone. The process is thus more commonly an osteo chondromatosis than a pure chondromatosis. The tumours may become detached and be free in the joint cavity.

CLINICAL FEATURES ATTENDING LOOSE BODIES IN JOINTS

Typically the presence of a loose body in a joint is associated, sooner or later with what may be termed a series of classical symptoms due to the impaction of the body between the opposing articular surfaces. While carrying out some movement the patient experiences a sudden intense pain in the joint. If it is the knee joint he usually

falls, and finds that the limb is apparently powerless. The joint is usually locked in a position of semi flexion and neither extension nor further flexion are possible.

There may be an obvious swelling at one part of the joint pressure on which will release the joint and terminate the attack or the body may become dislodged by some particular movement accidentally carried out by the patient himself. Occasionally however an anæsthetic must be administered before the joint can be unlocked.

After the attack there may be an effusion into the joint such recurrent synovitis is apt in time to lead to relaxation of the ligaments and instability of the joint.

A characteristic point in the history is the variable site of the pain in successive attacks it may occur at widely differing parts of the joint in contradistinction to cartilage lesions where the situation of the pain is constant.



FIG. 345.—Loose Body in the Elbow Joint

Atypical Symptoms In many cases the usual history may not be forthcoming and the reason for this becomes apparent when the pathological nature of the loose body is considered.

In the *pathological types of loose body*, the symptoms are usually masked by those of the major disease and the body may be overlooked in consequence. Multiple bodies e.g. multiple synovial chondromata are usually small and apt therefore to become impacted more frequently. The accident is not usually attended with the classical symptoms indeed it may give rise to remarkably little pain or inconvenience.

The *classical traumatic type of loose body*—derived from the articular surface—may be associated with puzzling symptoms at the beginning. The explanation of these is found in the degree of attachment that exists between the body and its bed for only where it has been completely cast off can the typical phenomena occur.

Fisher has described three forms of typical history.

1 An injury direct or indirect is followed almost immediately by classical symptoms but after an interval these disappear. Here, the body has been completely detached but after a time has acquired a secondary attachment to the synovial membrane.

2 An injury direct or indirect is followed after an interval by classical symptoms. Here the portion of articular cartilage has been

immediately detached, but has become at once adherent to the synovial membrane from which it has only become freed after a time.

3 A joint is subject to vague attacks of pain and swelling, there may be some creaking when the joint is moved, or some limitation in movement. The attacks increase in severity until eventually the classical picture is obtained.

Here the body has been gradually separating from its bed, and the occurrence of the classical symptoms coincides with its complete detachment. This type of history is often obtained in the so called osteochondritis dissecans.

DIAGNOSIS

X ray examination is invaluable in the diagnosis of loose bodies, which are osseous or osteo cartilaginous, and the film will also reveal co existing pathological changes. In connection with the knee joint, reference may be made in passing to an occasional source of error in the interpretation of X ray films. An appearance simulating a loose body is often given by a sesamoid bone in the lateral head of the gastrocnemius which is present in about 15 per cent of individuals, and frequently bilateral. It is recognized by its regular sharply contoured oval or circular form, and its constant position.

TREATMENT

A loose body which is giving rise to symptoms should be removed. When the body is free in the joint cavity, it is often a matter of considerable difficulty to locate it at the time of operation, it is often advantageous, therefore, to have the patient under observation for a day or two before operation. Should he at any time feel the loose body in a superficial position, the surgeon is informed, and, under aseptic precautions, the body is transfixed by a needle, the whole part is then carefully sterilized, and the body removed through a small incision under local anaesthesia.

If the history suggests a pedunculated loose body, which always makes its appearance at a definite spot there is no occasion for any delay in undertaking operation. When loose bodies are multiple in the knee joint and when a single loose body refuses to become palpable, the joint should be laid open by Timbrell Fisher's method.

Timbrell Fisher's Exposure. A slightly curved incision is made, commencing in the mid line 1 inch above the uppermost limit of the supra patellar pouch, and skirting the medial border of the patella and the medial border of the ligamentum patellæ to end a little to the inner side of the tibial tubercle. The flaps are reflected and a mid line incision made through the layer of fascia covering the quadriceps tendon the patella and the ligamentum patellæ. The medial fascial flap is now reflected well beyond the medial border of the patella and its ligament. Thereafter, it is strongly retracted, and the capsule divided $\frac{1}{2}$ inch from and parallel with, the medial border of the

patella The incision is carried obliquely upwards through the inner fibres of the quadriceps tendon care being taken to avoid incising any muscular fibres of the vastus internus Below the incision is carried through the capsule at the medial border of the ligamentum patellæ The synovial membrane is divided along the same line and the patella dislocated to the lateral side of the joint In this way an excellent exposure of the whole anterior compartment of the joint is obtained Occasionally the lateral part of the joint is obscured by the ligamentum mucosum which may have to be divided and subsequently resutured

This exposure may also be used for operations on the tibial spine and sometimes for operations on the cruciate ligament

Loose Bodies in the Posterior Compartments

When loose bodies are situated in the posterior compartment of the joint they may be removed by a median exposure through the popliteal space as advocated by Brackett

After the skin incision is made the dissection is carried down between the two heads of the gastrocnemius and since the branches of the tibial nerve run laterally it is recommended that the nerves and the vessels should be retracted to the lateral side The capsule is carefully cleared by blunt dissection to enable the loose body to be palpated before the capsular incision is made

For loose bodies in the postero lateral compartment an incision parallel to the anterior border of the iniceps may be used The biceps is retracted backwards the ilio tibial band divided longitudinally and the capsule opened either above or below the tendon of the popliteus The posterior horn of the lateral semilunar may be explored through a similar incision

When loose bodies are located in the postero medial compartment an incision may be made along the anterior border of the sartorius The muscle is retracted backwards and the capsule is opened behind the posterior margin of the medial ligament

PELLEGRINI STIEDA'S DISEASE

(Metacondylar traumatic osteoma)

This disease was first described by Kohler in 1903 although it is usually known by the names of two authors who wrote about it two years later The characteristic feature is the presence of a nodule of new bone or calcium in the region of the medial condyle of the femur The exact site is now believed to be the medial ligament of the knee It occurs usually in adult males and follows trauma which may be slight or severe and of either the direct or indirect type Following injury the earliest symptoms are those of a traumatic synovitis of the knee followed by a period of improvement though the knee never completely recovers indeed after weeks or months pain

and disability may increase until a point is reached at which they are stationary. Movement is then considerably limited and there is tenderness over the medial condyle, and often the condyle appears hypertrophied on palpation.

It is doubtful if such deposits really are the cause of much disability. It is not unlikely that the symptoms so often attributed to them are due to the associated or basic lesion—e.g. sprain of the medial ligament of the knee.

The condition is most commonly unilateral. Bilateral involvement is rare. An X-ray examination is essential for diagnosis and shows a bony shadow alongside the medial condyle which may be uniform or composed of a series of separate small deposits. They are usually first seen about the level of the knee joint and while in early cases they are quite separate from the condyle in late cases the shadow may appear to be continuous with the condyle.

The histological structure of the nodule varies. It may consist of a deposit of lime salts amongst the fibres of the medial ligament or may be composed of formed bone.

ETIOLOGY

On analogy with similar disturbances—traumatic myositis ossificans—it may be presumed that as a result of trauma there is hyperæmic decalcification of the medial condyle at the site of attachment of the medial ligament. The abstracted calcium is redeposited in the ligament and may provide the local excess of calcium demanded for the formation of bone. Occasionally the nodule disappears completely in the course of time but more often it enlarges till it attains a certain size at which it persists. Very rarely it may grow to a mass of considerable size and give rise to mechanical disability.

In early cases rest in bed and gentle active movements with the application of radiant heat is usually sufficient. In established cases with a well marked area of calcification an early restoration of full function must not be expected. The disease is self limiting and provided the case is not over treated a full recovery may be expected in 2-6 months. The slow return of flexion in such a case may provide the temptation to use passive movements or even manipulation. These forms of treatment delay progress. The patient's own active flexion to a point short of producing pain together with quadriceps exercises will eventually produce complete recovery.

Surgical removal is seldom indicated but might be necessary if the deposit attained a size of such dimensions as to cause definite mechanical interference with the function of the joint but only when it has reached its maximum size and is in an entirely quiescent state.

CHAPTER XVI

AFFECTIONS OF THE FOOT

STATIC DISTURBANCES OF THE FOOT

At all ages foot disabilities contribute largely to the work of orthopaedic clinics. A proper conception of the mechanism of the foot in health and disease is therefore of paramount importance.

The human foot has become greatly specialized for the performance of two divergent functions:

1. In standing it must provide a stable support for the body weight—its static or passive function.

2. In walking it must in addition to supporting the body weight provide a resilient spring or lever by which the body can be propelled forwards—its dynamic or active function.

These objects are fulfilled by the architectural arrangement of a number of small spongy elastic bones grouped together in the form of a series of arches.

In addition to conferring resiliency to the foot the arches serve for the dispersal of force applied to the plantar aspect of the foot and they provide necessary space for the passage of nerves and vessels forwards towards the soles.

A. The Longitudinal Arch extends from the calcaneus to the head of the first metatarsal, its summit being placed at the mid tarsal joint. The posterior pillar of the arch is short—from the calcaneus to the joint—whereas the anterior is long and its slope more gradual.

The means used to maintain the arch—or any arch—can be divided into three main groups:

1. The segments may be attached to each other on the side of the concavity. Fig. 346 (1).

2. The supporting pillars may be attached to each other. Fig. 346 (2).

3. A strap may be passed under the highest part of the arch and being attached to structures at some distance from the arch thus suspends it. Fig. 346 (3).

All of these methods are illustrated in the supports of the longitudinal arch—

(a) The intersegmental connections are represented by the ligaments which bind the individual tarsal bones together and which are very strong on the plantar aspect—the spring ligament and the long

and short plantar ligaments the plantar fascia and by the muscles—the abductors the short flexors and the quadratus plantæ

(b) The pillars are firmly secured to each other by the muscles and fasciæ which extend from the calcaneus to the great toe

(c) The tibialis posterior passes under the highest part of the arch and its expansion is attached to the cuboid it therefore acts as a supporting strap

Variations in the height of the arch are achieved by alteration in the position of the talo navicular joint induced by the contraction or relaxation of the tibial muscles despite this the arch is to some

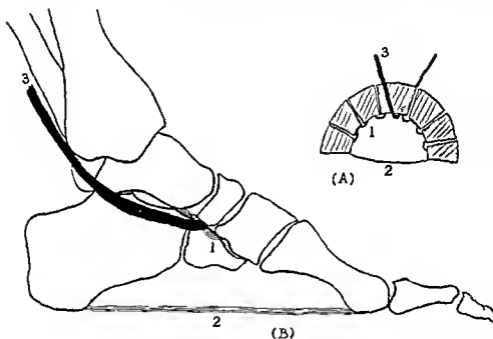


FIG 346 The etiology of Supporting Arches (A) Structural (B) The human foot. (After Frazer)

extent permanent and gross alterations in its composition are to be regarded as pathological

B The Transverse Arch becomes apparent when the feet are placed together. It extends from the lateral border of one foot to the lateral border of the other and has no true summit as the medial malleoli prevent the absolute apposition of the medial borders of the feet

C The Anterior Metatarsal Arch disappears with weight bearing. It extends from the first to the fifth metatarsal heads and its summit is placed opposite the heads of the second and third metatarsals. Normally the anterior arch has no great weight to sustain and it derives adequate support from the transverse inter metatarsal ligament connecting the plantar aspects of the heads of the bones

D The Internal Arch is formed by the medial border of the foot and its concavity is directed medially

Despite occasional assertions to the contrary it is reasonably certain that the arches of the foot are present at birth in that the cartilaginous skeleton of the foot has already assumed an arched formation. When the child begins to support the body weight however it will be seen that the foot becomes flat and does not develop for some years an arch which persists during weight bearing. This is due to the fact that though it possesses its arch as an inherent right the factor most potent in the preservation of that arch has not yet been acquired that factor is the postural tone of the long tibial muscles which is a late human development. In the foot of the orthograde primate the tibial muscles are concerned with the active movement of the metatarsus on the tarsus and have no postural activity. Should they fail to develop in the human child the original arches of the foot are flattened out by weight-bearing and the arches are never restored—as in the so called congenital forms of flat foot.

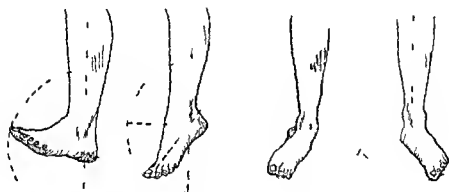


FIG 347 —The Movements of the Normal Foot

The Movements of the Foot

It is usual to include the ankle in any consideration of movements of the foot. The movements at the ankle joint consist of plantar flexion and dorsal flexion.

When the whole foot is rotated on an antero posterior axis so that the sole faces medially it is said to be inverted the opposite movement is eversion these actions occur mainly at the subtalar joint.

The anterior part of the foot is able to move on the posterior part on a vertical axis when the forefoot is thus brought in towards the midline of the body it is said to be adducted. The counterpart of adduction is abduction and these movements also originate at the talo navicular joint.

When the foot is in a position of abduction and eversion it is sometimes said to be pronated supination similarly consists of a

combination of adduction and inversion

These terms are confusing and should be avoided



FIG 348—Specimen of a Congenital Fusion between the Calcaneus and the Navicular—a rare cause of foot weakness

FLAT FOOT

The factors which in combination preserve the long arch of the foot have already been considered—viz the shape of the bony segments composing it the plantar ligaments and the postural activity of the tibial group of muscles

It follows therefore that flat foot may arise either as a congenital or acquired deformity as a

sequel to interference with one or other of these factors

Congenital flat foot while it may result from anomalies in the development of the tarsal bones is largely due to failure on the part of the tibial muscles to acquire the postural tone necessary to preserve the arch for the arch though present at birth is speedily obliterated by the body weight

Acquired flat foot may be—

- Osseous
- Ligamentous
- Muscular—paralytic
spastic
postural or
static

The *osseous* variety may result from trauma to the bones (e.g. in run over fractures fractures of the navicular or calcaneus) or from disease of the bones

The *ligamentous* variety may follow rupture or avulsion from their attachment of the plantar ligaments



FIG 349—Congenital type of Flat Foot sometimes called a mallet foot

In the *paralytic* and *spastic* muscular types the flattening of the arch is a secondary and late effect due to the effect of weight bearing on a foot whose position has been altered by the muscular error. They are considered separately in Chapter X.

The *static type of acquired flat foot* is one of the most common and important of orthopædic complaints.

The Mechanism of Static Flat Foot

Flat foot arises when the postural muscles of the longitudinal arch become unable to fulfil their function. These muscles may prove defective when—

(1) *There is a general muscular hypotonus.* Convalescence after illness or after childbirth for example is apt to be associated with loss of muscular tone. Also when growth is rapid the muscular development may lag behind the growth of the other tissues. Severe trauma to the leg which is complicated by muscular atrophy is also a cause.

(2) *When normal muscles are excessively fatigued.* This may happen in occupations in the course of which the individual has to stand or walk for hours at a time and is common for example amongst nurses, policemen and soldiers or it may follow excessive exercise after a period of relative disuse as in the typical case of the clerk who sits at his desk all week and indulges in long country walks during the week end.

Relative muscular insufficiency may be caused by a rapid increase in the body weight and is commonly associated with obesity. The type of flat foot for which it is responsible is often found in conjunction with the rapid increase in the body weight of women at the menopause and is the explanation of the foot symptoms so often complained of at that time.

Excessive fatigue may also result if the muscles of one limb have to bear a disproportionate share of the body weight as for example when the two limbs are of unequal length through lesions of the bones or joints or when one limb has been amputated.

In addition to these precipitating causes there are certain *predisposing factors* viz.

(i) *Faulty Footwear.* The modern shoe has several bad features two of which deserve mention. The pointed shape displaces the great toe laterally and crushes and distorts the other toes and the more or less unyielding leather that is used particularly for the sole of the shoe tends to cause atrophy of the muscles of the foot.

(ii) *Bad walking.* The method of walking once taught in military schools is particularly bad for the recruit is taught to walk with the toes pointing laterally in which position he throws an undue strain upon the long arch of the foot and on its supporting muscles.

(iii) *Loose Methods of Standing.* When much standing has to be done it is an advantage to the feet to attempt to invert them at frequent intervals. Standing with the feet everted puts an undue

strain on the ligaments of the inner side and tends in time to produce a condition of weak foot in those who have to be on their feet for long periods. Under these circumstances it is important to invert and adduct the feet at frequent intervals.

(iv) *Varicose Veins* Varicose veins are frequently found in association with flat foot in the adult and it is supposed that the chronic congestion leads to œdema of the tarsal ligaments and the chronic oxygen deficiency interferes with the efficiency of the muscles on which the arches depend. The observation has an important practical bearing for in most cases attempts to improve the foot condition are unsuccessful until the varicose veins have been either cured or controlled.

PATHOLOGY

In the earliest stages of flat foot there may be few or no appreciable changes as the calcaneo navicular ligament yields however the head of the talus is pressed forwards downwards and medially and the body of the talus may glide forwards on the upper surface of the calcaneus. The calcaneus itself is deviated to the medial side and its anterior end depressed with the result that the sustentaculum tali the head of the talus and the tuberosity of the navicular come to form prominences on the medial aspect of the foot. The long and short plantar ligaments also yield gradually and eventually the deltoid ligament of the ankle as well. When the foot is viewed from behind the tendo calcaneus appears to be deviated laterally the tibial tendons are seen to be overstretched and the peroneal tendons adaptively shortened.

In neglected cases two further changes ensue the displaced bones are gradually altered in shape the navicular and medial cuneiform bones for instance becoming shaped like wedges with the apices situated dorso laterally and there is a permanent alteration in the set of the tarsal bones which amounts to a subluxation at the tarsal joints secondly portions of the joint surface now unused eventually show fibrillation of the articular cartilage and osteoarthritic outgrowths appear at the margins.

SYMPTOMS

In the first stages the patient notices that the feet are hot and uncomfortable—they burn after use and perspire more freely than normally. Later comes stiffness and lameness and the feet become stiff after sitting or resting and are most uncomfortable when the patient rises in the morning. With prolonged use the feet suffer and such patients are particularly unhappy after an active day's exercise though they are comfortable again after a day of rest. The gait becomes inelastic and clumsy and there is a tendency to walk with the feet everted and not to rise on the toes.

Pain Pain is more severe when standing than when walking since walking involves chiefly the use of muscles whereas in standing

the weak muscles relax and the whole body weight is borne by the weakened ligaments. The pain is experienced in several situations—under the tubercle of the navicular (from stretching of the inferior calcaneo navicular ligament) below the medial malleolus along the talo-calcanean joint on the medial surface of the calcaneus and in some cases the tip of the lateral malleolus and the lateral surface of the calcaneus may be painful as well as the dorsum of the foot. The pain is due to the stretching of the ligaments and the compression of the tissues below the lateral malleolus.

Occasionally teno synovitis of the tibia posterior or of the peroneus longus is present and in severe cases the whole foot is so swollen and painful that walking is difficult and the gait reduced to a mere shuffle which reduces the muscular action of the foot to a minimum.

Tenderness The commonest areas of tenderness are over the navicular the inferior calcaneo navicular ligament the sole of the foot and frequently below the head of the first metatarsal.

Swelling of the Foot Localized puffiness is common and in chronic cases oedema of the feet may occur. Sweating is marked.

Gait In flat foot raising of the heel is avoided to prevent strain being put upon the tarsal and the metatarsal ligaments and the patient carefully lifts the ball and the heel of the foot together. The toes are usually turned outwards—splay foot—and the gait is thus awkward and stiff and without any spring.



FIG. 301—Valgus Deformity of the Feet as seen from behind

The Deformity In the early stages no deformity is visible and the arch is well formed but it must be borne in mind that this is the period when the other symptoms—pain tenderness and oedema—are most severe because the supporting tarsal ligaments which react to severe and chronic strain in the same way as the ligaments of other joints are just beginning to yield.

It is sometimes difficult to determine the extent of any deformity



FIG. 300—Weak Abducted Feet

that has arisen for the height of the longitudinal arch is very variable indeed it has been pointed out by Lovett that it is the high arch which is most prone to break down and it follows that in this event symptoms may be severe with only slight depression of the arch

The first deformity consists usually of eversion of the foot without flattening of the arch. The flattening becomes apparent at a later stage and then when the foot is inspected the head of the talus is found to stand out prominently in the medial border of the foot

Stiffness and Muscle Spasm Where muscle spasm is marked the foot resists passive correction into an inverted position and in time becomes rigidly fixed by the formation of adhesions in the joints which are subjected to irritation. In severe cases the peroneal muscles are tightly contracted and can be seen standing out under the skin. Attempted correction induces pain along the course of these muscles

The spasm may implicate the gastrocnemius and the soleus and thus lead to progressive deformation of the foot

Pressure Symptoms The medial part of the sole of the boot wears more quickly than the lateral. The skin along the medial border of the heel and foot is thickened and painful and a callous ridge may form in this situation. Painful corns may form too in the weight bearing areas under the heads of the metatarsals

The lateral displacement of the foot often forces the little toe against the leather of the boot and induces the formation of a callosity or corn on its most prominent part. The toes are compressed laterally even when the boot is not too narrow

The effects and symptoms of flat foot are not always limited to the feet as additional lesions may result from the disturbance of the static equilibrium of the body. Thus synovitis may occur in the knee, backache is often present with pain in the buttocks and in the sacral region the hip joints may also be painful and irritable

TYPES OF WEAK FOOT

From the point of view of treatment it is useful to divide flat foot into five classes or stages though it should be understood that the stages gradually merge into one another and that there is no sharp line of distinction between them

1 Foot Strain or Incipient Flat Foot This is the earliest stage and corresponds to the period when pressure is first being exerted upon the ligaments. There is no evident deformity but tenderness and pain may be so severe that the patient is confined to bed

2 Voluntary flat foot corresponds to the stage at which flattening of the arch has occurred but secondary adaptive changes have not yet ensued. The tibial muscles in particular, though they have lost their postural tone have not been sufficiently over stretched to interfere with their power of voluntary contraction

When the patient is standing there is quite evident flattening of the arch but when the foot is raised from the ground the arch is restored.

3 Resistant Flat Foot In this type secondary adaptive changes have supervened but though the foot resists any voluntary effort to reduce the deformity it can be corrected by manipulation.

4 Rigid Flat Foot In this type the deformity cannot be corrected even manually. If however an anæsthetic is administered the foot can then be forcibly reduced either by hand or by means of a Thomas's wrench.

5 Permanent Flat Foot In this type no amount of manipulation even under anæsthesia will restore the arch since changes in the



FIG. 3.—Flat Foot. (1) dropped Longitudinal Arch. (2) Pronounced the Navicular. The rigid type.

form of the bones have taken place. If correction is essential it has to be obtained by an operation involving the removal of bone.

EXAMINATION OF THE FOOT

The examination of the foot should be conducted according to a definite plan for with a constant procedure minor degrees of derangement are more easily recognized.

Inspection The examination should commence by observing the manner of standing and walking. Any limp is noted and the elasticity of the gait and the posture of the feet in walking observed. Deformity of the shoes—excessive wearing away of the sole on the medial side, bulging of the medial side of the gait, or the presence of localized prominences—is noted as the patient removes them.

The patient now stands barefooted before the surgeon and the attitude, the shape and the weight distribution of the foot is investigated. The long narrow foot is prone to foot strain. The line from the centre of the patella down the tibial crest should pass through

the space between the second and third toes in foot strain it constantly passes to the inner side of the great toe

In addition the medial border of the foot may be convex instead of concave, and the head of the talus or the navicular may stand out as a distinct bony prominence on the medial side of the foot

In slight cases the persistent eversion of the foot may not be pronounced from the front. In such a case, examination from behind frequently prevents error in diagnosis, as the medial malleolus is seen to be unduly prominent and the angle between the leg bones and the talus and calcaneus is more obvious

Palpation The foot is now carefully palpated for evidence of abnormal tenderness. This is usually present on both the medial and lateral aspects of the ankle, in the first case because of ligamentous strain and in the second from the crushing of the soft tissues between the lateral malleolus and the everted foot. Pain is present on the sole, especially over the spring ligament

Movements of the Foot The various movements are carefully and systematically tested. The calcaneus is firmly grasped in one hand with the tuberosities resting in the palm, the bone is fixed with the thumb and fingers, and the movement of the forefoot at the mid tarsal joint estimated

When the leg is grasped above the ankle by one hand, and the foot at the mid tarsal joint with the other, the motion at the subtalar joint can be gauged

The range of plantar and dorsiflexion at the ankle is tested last, in the usual way

The error can now be classified as voluntary, passive, or rigid according to whether it can be corrected by a voluntary change in the position of the foot by manipulation on the part of the examiner, or not at all

DIAGNOSIS

The diagnosis of weak, or flat, foot should not be difficult. Certain conditions may sometimes have to be differentiated, and these are injury, toxic arthritis, synovitis, bursitis, tendonitis, infantile paralysis, Kohler's disease, osteochondritis of the calcaneus and tuberculosis

PROGNOSIS

The prognosis in flat foot depends upon the stage at which treatment is instituted, and upon the perseverance with such treatment. Without treatment, no cure is possible, and the patient is usually forced to seek relief because of steadily increasing pain and disability. The pain may completely disappear after some years, when the long arch has been completely broken down, but by that time the foot is irreparably damaged, and useless as a lever in the production of normal gait

In the rigid type the course is protracted and the prognosis is guarded. Whitman says that to cure the condition one year's treat-

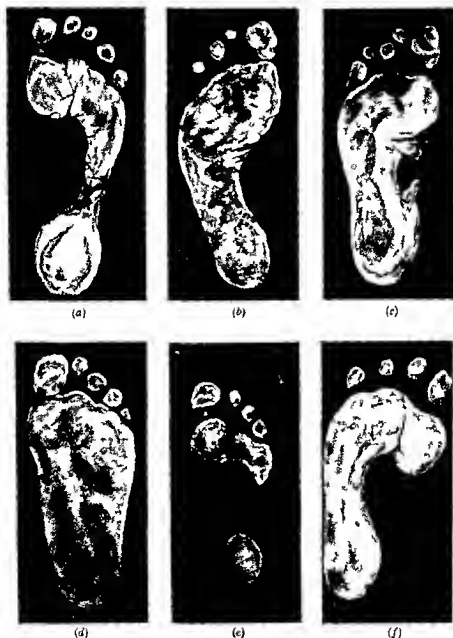


FIG. 33.—Deformities of the Foot. The various appearances of sole impressions. (a) Normal foot. (b) Compensating flat foot. (c) Moderate flat foot. (d) Severe flat foot. (e) Pes cavus. (f) Pes excavatus (cavus). (After De Quervain.)

ment will usually be required but that thereafter the shoes need attention indefinitely.

TREATMENT

General Considerations.

No condition in the practice of orthopaedic surgery has been subjected to so many varieties of treatment as flat foot. Its cure is attempted by numerous methods, from alterations in the footwear to transplantation into the outer side of the tarsus of large wedges of bone resected from the medial side.

The objects of treatment may be formulated thus:

1 To correct the abnormal centre of gravity in the foot, so that the body weight is transferred to the outer side of the foot.

2 To remove pressure symptoms.

The absolute indications for treatment are pain and the impaired function. The existence of flat foot does not necessarily mean that treatment is required, as many people with perfectly rigid feet are able to go about their ordinary occupations without the slightest discomfort. Treatment will be discussed in conformity with the type of case to be treated.

Treatment of the Incipient Flat Foot (Acute Foot Strain)

In severe cases of foot strain, where the foot is œdematous and movement exquisitely painful, it is often advisable to recommend a period of rest in bed. This can be supplemented by various physiotherapeutic procedures to promote the disappearance of the œdemata and improve the nutrition of the small muscles of the foot. Among such procedures may be noted:

(1) *Massage* Massage of the deep rotatory type is useful, and should be carried out twice daily, sometimes with the application of olive oil or cocoa butter. In older children or adults where pain is very marked, an anodyne ointment should be used. Lewin suggests one containing Salicylic Acid, Menthol and Camphor.

(2) *Contrast Foot baths* Contrasted foot baths are prescribed for older children and adults. Two buckets are used, each big enough to contain both feet. One bucket contains warm water, and the other cold water, and the patient sits in front of them and places the feet in the warm water for a minute, and then in the cold water for a similar period. This treatment is carried out for ten minutes.

(3) *Electrical Treatment* Faradic stimulation of the small muscles of the foot is most effective in increasing their tone, and may be done either by the surging method or by stimulating each muscle individually.

It will be found that even in the most acute types, such treatment affords speedy relief, but the after care is equally important. An endeavour should be made to eliminate any predisposing factor which appears to operate in the particular case, thus adjustment of the diet in the obese, the injection of varicose veins, the correction of faulty attitudes, and attention to the footwear are of vital importance. When first allowed up it may be wise to reinforce the lathy

relaxed ligaments by *adhesive strapping* which forms a valuable method of support and is applied in the following way. The patient sits facing the surgeon with the knee flexed and the heel on the surgeon's left knee. The foot is dorsiflexed and the arch held as high as possible.

A strip of adhesive plaster is now carried from the lateral side of the foot underneath the central part of the long arch and fixed to the antero-medial surface of the leg in such a way that its anterior edge can be made smoothly adherent to the dorsal surface of the instep. A second strip is then placed over the first in the same manner except that its anterior edge is held up an inch further forward. Over these two strips are then placed numerous figure of eight strips circling the foot and ankle. The strapping should be renewed each week until symptoms are entirely absent.

CORRECTION OF FOOTWEAR. The proper shoe has a slightly concave inner border to favour adduction; the toe cap is deeper over the great toe than elsewhere and the width of the shoe is equal to or a little greater than that of the weight-bearing portion of the foot when standing. It is firm behind but flexible in front of the mid-tarsal joints; tight over the instep and with a low broad heel which must grasp the heel of the foot. Due allowance must be made for rapidly growing feet.

In the fitting of shoes the waist of the shoe should be accurately moulded; if it is loosely fitting the weight of the body when walking downhill is taken on the points of the toes whereas a tight waist will prevent this.

Flexible shoes are indicated only when the patient needs exercise but most of the patients seen by the orthopedic surgeon e.g. patients with flat foot need both exercise and support and the latter need is supplied only by a rigid or semi-rigid shank. It should be remembered that it is useless advising women to wear a low broad heel when they have been used to a high one all their lives. The low heel merely increases their misery since it strains the calf muscles. In such cases the patient is advised to wear a correct shoe for walking and when at home when they go to dances and have to dress accordingly they are allowed to wear any type of shoe that will fit the foot even though by this they are undoing some of the good derived from wearing proper shoes at other times.

Following acute foot strain it is important to thicken the medial part of the sole by about a quarter of an inch a device that deflects the body weight to the lateral part of the tarsus and spares the longitudinal arch to some extent.

It is important that children should be properly fitted with correct shoes and this is often difficult as many children outgrow rather than outwear their shoes. They should be fitted with a Thomas's heel the function of which is to transfer the body weight to the lateral border of the foot and which when properly made, thus compels the foot to assume a proper walking angle.

It is also essential to insist on a course of exercises at this stage before actual collapse of the foot has ensued. These are directed towards

1 Instruction in walking

2 Improvement of the muscular support of the arch

(1) *Instruction in Walking* The patient should be taught to walk with the feet parallel as the muscles supporting the arch are then made active and therefore produce adduction and inversion of the foot. The heel and toe walk also brings strong muscles into play and should be cultivated. When standing the patient should ensure that the weight is borne on the lateral side of the foot the foot should never be held pronated or relaxed.

(2) *Exercises* Exercises active and against resistance should be carried out twice daily. This treatment is tedious for adults but they should be encouraged to persevere in its performance. In children the exercises can be so modified or carried out to music that they are considered part of an amusement. The rationale of the exercises is to stretch shortened structures such as the tendo calcaneus and the soft parts on the lateral side of the foot and to strengthen the relaxed muscles so that they are in a better condition to support the arch and keep it free from deformity and its ligaments from strain. Essentially they all consist of rising on the toes and on the lateral side of the foot. They are done slowly and the feet should not be allowed to come down too rapidly.

The patient is instructed to perform his exercises in bare or stockinged feet. They may be carried out standing or sitting according to the severity of the symptoms but of whatever type they should aim at strengthening the adductors and plantar flexors.

(a) *Non weight bearing Exercises* These exercises may be begun during recumbency or when the patient is allowed up in which case the patient sits on a chair with his legs crossed.

The exercises for the toes without weight bearing are flexion and extension of the toes for the foot strong plantar flexion adduction and inversion of the forefoot and finally dorsiflexion. The patient should be taught to rotate his foot drawing the letter O with the point of his great toe. The exercises should be performed actively and thereafter the patient should carry them out by forcing the foot into various positions with the opposite hand while the affected foot is supported on the opposite knee.

(b) *Weight bearing Exercises* Weight-bearing exercises should be begun as soon as the pain and muscle spasm have subsided. Of these the best is walking in which the leverage power of the foot is properly employed and in which the two feet are nearly parallel. The following list of additional exercises will be found useful.

(i) *Tip toe Exercises* The patient places the feet side by side in an attitude of slight adduction raises the body on the toes to the extreme limit the limbs being fully extended at the knees, then sink

ing slowly rests the weight on the lateral border of the feet in the attitude of marked varus

(ii) *Rising on the Lateral Borders of the Feet* The patient stands with the feet parallel and rises on the lateral borders of his feet without twisting the legs or bending the knees. This movement takes place at the subtalar joint and calls only the adductors of the foot into play.

(iii) *Walking on the Lateral Borders of the Feet* With the feet parallel the patient rises on the lateral borders and walks in this position. If he walks with the toes turned in the rotators are brought into play also. The big toe should be curled downwards.

(iv) A similar exercise may be carried out where the patient lifts the foot so that it is opposite the other knee. He walks across the room several times with this ostrich step, always bearing his weight on the lateral border of the foot.

(v) *Walking backwards and forwards on a supination board* which consists of boards joined at their longitudinal edges at an angle of 165 degrees. The patient walks the length of this board (8 feet) three or four times as one would walk on the eaves of a house.

(vi) The feet are held parallel and the knees extended. The knees are then rolled laterally so that the long arch automatically rises.

(vii) *Bicycling on a machine* in which the medial parts of the pedals are thickened.

(viii) The ball of the foot is placed on the sharp edge of a thick board, table or some other support with the toes projecting over the edge, and the toes are deliberately bent downwards as far as possible. If the toes do not bend readily they become more flexible on manipulation by the hands.

All patients who have weak feet need instruction in correct standing and walking. Exercises in correct walking should be practised with the medial border of the foot elevated as in this position it is impossible to bear the weight of the body anywhere but on the heel and lateral border of the foot, they should be carried out at home twice a day, and, to ensure regularity, the patient should be under the direct supervision of a physician. Alternating hot and cold foot baths stimulate the circulation and are of value in restoring tone to weak muscles.

In children games may be utilized as exercises. Ballet dancing is an excellent exercise, and may be started at the age of 4 or 5, but toe dancing should not be carried out by children with any tendency to weak feet, nor is it good for any children. Swimming and



FIG. 354.—Exercise for Weak Feet

Walking on an angled board to correct the valgus deformity

roller skating are very good but children should never be allowed to use scooters since they tend to cause both knock knee and flat foot

Treatment of Voluntary Flat Foot

In this type where the deformity can be corrected by the patient at will the treatment proceeds along the lines already laid down. When pain is prominent rest in bed and strapping are again employed till the acute phase has subsided. The after care is similar but in addition to the other measures an arch support may be employed. The best types of arch supports are of felt or sponge rubber.

(a) *Felt Supports* Bevelled felt pads by affording a resilient support thereby increase the spring of the gait they are very efficient and preferable to rigid supports of celluloid metal or leather. The pads are actually inserted into the shoe and held in place by means of special glue and tacks. They fit into the natural hollows so that no extra space is required.

(b) *Sponge Rubber Supports* Supports made of sponge rubber have the same advantages as bevelled felt and are even more resilient in addition they are more easily cleaned and retain their resiliency for a longer time.

Treatment of Resistant Flat Foot

The treatment of this type where the foot can be manipulated into the correct position by the surgeon is very similar to that of the voluntary type but a Whitman's valgus brace is recommended instead of felt or sponge rubber supports.

The Whitman Valgus Brace This most efficient appliance by claspings and holding together the weak part of the foot serves effectively to restrain deformity and to ensure such an attitude that the patient cannot avoid using the muscles which abduct and invert the foot.

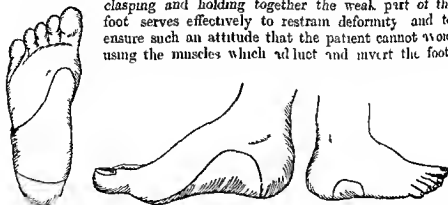


FIG. 30.—The Whitman Support as used in the correction of antero-posterior flat foot (Whitman)

It is indicated in cases where the foot is still flexible and can be passively replaced in its correct position. It is particularly useful for the flabby type of flat foot and where there is no bony prominence on the inner border but it should not be used for rigid cases until the deformity has been reduced by manipulation. The brace is made for each individual from a cast of the foot (FIG. 30). It is

made of duralumin or aluminium, and consists of three parts—first, the main part, fixed to the sole and extending from the centre of the heel to a point behind the ball of the great toe, second, a broad, medial upright portion, rising from the navicular bone and protecting the talo navicular joint, thirdly, a lateral arm covering the calcaneo-cuboid joint and holding the foot securely. The brace has to be worn for from three to twelve months according to the condition of the patient and the amount of strain to which the foot is subjected. It may require alteration during the first few months of use, as the arch may need to be raised at intervals or the whole brace made narrower in order to grasp the foot more tightly.

Treatment of the Rigid and Permanent Types

In these cases it is important to understand why symptoms arise as the ligaments have already been stretched to their full extent they are unlikely to be the cause of pain, and any symptoms are most probably due to the formation of adhesions or the occurrence of osteoarthritic changes in those tarsal joints which still retain some mobility, in both cases, symptoms are relieved by manipulation under anaesthesia. Following the manipulation the patient should have a course of vigorous exercises to preserve the mobility gained by the manipulation.

Manipulation. When the patient is anaesthetized some of the rigidity will be found to have been due to muscle spasm, and to have disappeared. If any restriction of movement remains, the foot is forcibly manipulated by a Thomas's wrench, until it is absolutely flexible and flaccid, it is forced first downwards, then medially and upwards into extreme varus, and an attempt is made to get the lateral border of the inverted foot up to a right angle with the leg.

In this type it is usually impossible to restore the arch and attempts to do so, followed by encasing the limb in plaster of Paris for a period of many weeks are doomed to failure—indeed the immobilization in plaster adds to the muscular weakness already present the atrophy of disuse, and when the plaster is discarded the thin and wasted limb is in an even worse plight than before.

Where symptoms persist despite manipulation, recourse may be had to operation, the tarsal joints being arthrodeshed. Ankylosis may be secured by a triple arthrodeshesis after the method of Naughton

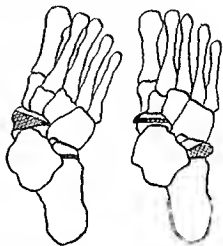


FIG. 356.—Operation for Rigid Flat Foot.

A wedge of bone is excised from the navicular and inserted into a prepared bed in the cuboid.

Dunn, or a less extensive talo navicular arthrodesis, or some modification of it. Naughton Dunn's procedure is described elsewhere (page 510).

(a) *Talo Navicular Arthrodesis* The foot is thoroughly manipulated until it is flaccid and mobile. A 2 inch incision is then made, beginning in front of the medial malleolus and extending along the course of the anterior tibiotalar tendon. The tendon is retracted and the dorsal aspect of the talo navicular joint exposed by freeing the overlying ligaments and strongly flexing the foot. The joint is denuded of ligaments and the capsule opened. A curved gouge is used to excise the articular surfaces of the talus and the navicular, but care is taken to preserve the ovoid shape of the head of the talus and the convexity of the navicular, so that when the forefoot is again adducted into its proper corrected position, the navicular will rotate and remain in contact with the denuded head of the talus.

(b) *Talo Navicular Arthrodesis, plus wedge insertion to outer side of the foot* In this operation, the steps of the talo navicular arthrodesis are similar to the above, but in addition, a wedge of bone is removed from the navicular and inserted, through an incision on the lateral side of the foot into a bed prepared for it in the antero-lateral part of the calcaneus. In most cases the foot is put up in plaster of Paris in the corrected position for twelve weeks, thereafter the ordinary treatment of flat foot is carried out.

PERONEAL OR SPASMODIC FLAT FOOT

This condition is included as one of the types of flat foot although it is really a separate condition, the etiology of which is obscure. It is seen most commonly in adolescents who complain of pain and who, on examination, reveal a foot firmly fixed in extreme eversion by spastic contraction of the peroneal muscles.

Many theories have been advanced to explain the origin of this condition but none has received general acceptance. It would appear, however, that the lesion is situated in the talo navicular or calcaneocuboid joints and Lorenz has shown that injection of local anæsthesia into these joints frequently abolishes the spasm temporarily. It is probable that the condition is a toxic synovitis or arthritis associated with a septic focus most frequently situated in the tonsils. The strain of prolonged standing or unduly heavy work in adolescents who have recently left school may be the localizing factor.

Patients who have received an intra articular fracture of the talus or navicular frequently exhibit a similar condition, and this may be taken as further proof that the lesion is one of protective spasm to abolish movement at the mid-tarsal joint.

In the absence of treatment secondary organic shortening of soft structures and alteration in the shape of the bones takes place so that the final stage is a rigid or permanent flat foot.

TREATMENT

The possibility of the presence of an active toxic focus is investigated the tonsils being especially suspect. The removal of septic tonsils may sometimes be followed by a complete recovery.

Tenotomy or excision of portions of the peroneal tendons or crushing of the motor branches of the musculo-cutaneous nerve have been practised but such treatment being directed to the effect rather than the cause seems unreasonable. The most satisfactory results are obtained from prolonged immobilization in plaster. Under anæsthesia which relaxes the peroneal spasm a plaster case is applied in the mid position. The grossly over-corrected inverted position is inadvisable. Following a period of rest of about four weeks duration the plaster is converted into a walking plaster and immobilization continued for a further six weeks. When the plaster is finally removed the patient practices graduated active foot exercises in the manner already described and Thomas heels are fitted to the shoes. In resistant cases the use of a lateral iron and inside T strap is advisable for some considerable time.

AFFECTIONS OF THE BONES AND JOINTS OF THE METATARSUS

The Normal Form of the Forefoot

The metatarsal bones are usually arranged as a parallel series and the first metatarsal is thicker and stronger than the others as it provides the weight-bearing foot with one of its three chief points of support further because it forms the fulcrum on which the body weight is swung forwards in walking its head lies on a more anterior plane than the others. The other important weight-bearing points of the foot are the fifth metatarsal and the calcaneus and these with the first metatarsal head are usually regarded as forming the points of a tripod.

The intermediate metatarsal heads are sometimes said to form an arch—the *anterior metatarsal arch* but the accuracy of this observation is doubtful. It is more than likely that all the metatarsal heads are in contact with the ground in walking but that as a result of muscular and ligamentous support they take relatively no part in weight-bearing under normal conditions.

Developmental Anomalies of the Metatarsus

Alterations in the normal form of the forefoot are common and consist of atavistic anomalies of the first metatarsal. In the course of development the first metatarsal is gradually drawn laterally from an abducted position into parallelism with its neighbours it loses the mobility it possesses in the primitive foot of the ape and it grows in strength till it outstrips its fellows.

The common developmental errors which may occur are

(1) *Metatarsus Primus Varus* Here the first metatarsal is distinctly abducted from the midline of the second and there is a palpable and radiologically demonstrable interval between the first and second heads. Occasionally this wedge shaped interval is occupied by an accessory ossicle—the *os inter metatarseum*.

(2) *Metatarsus Atavicus* In this anomaly the first metatarsal bone is shorter than normal and its head is situated behind the head of



FIG. 3. Hallux Valgus with Metatarsus Primus Varus

the second and commonly the third. The metatarsal is often abducted (primus varus).

(3) *Metatarsus Hypermobile* where the first metatarsal is unusually mobile. This is the result of ineffectual fixation at its base and can be demonstrated easily by taking the metatarsal head between the finger and thumb and plantar and dorsal flexing it at its base while the tarsus is supported by the opposite hand.

The Clinical Effects of Developmental Anomalies In many people the possible ill effects attending developmental errors are masked by efficient muscular support and by hypertrophy of the neighbour

ing bones, but it is obvious that certain effects may arise in them. In *metatarsus primus varus*, the first metatarsal is lying away from the long axis of the foot and fails to act as an effective fulcrum its function therefore must in part be assumed by the second metatarsal, and possibly the third and these—unless hypertrophied—are ill adapted to fulfil its purpose. In *metatarsus minoris* a similar effect obtains while in *metatarsus hypermobile* the first metatarsal though it may act as a fulcrum quite effectively if fixed by the adductor muscle, without such fixation fails to form a stable weight-bearing point of the tripod and becomes splayed out on long standing.

There is one further—and important—effect of *metatarsus primus varus*, the use of even ordinary footwear will cause the toe to become displaced in effect that will be enhanced by the use of boots or shoes with abnormally pointed toes. The increased load thrown on the intermediate metatarsal heads is the factor underlying a train of interesting and important disturbances.

The following clinical conditions may arise therefrom in association with developmental anomalies

- 1 Hallux Valgus
- 2 Metatarsalgia
- 3 March Foot or March Fracture
- 4 Kohler's Disease of the Metatarsal Head (Freiberg's infraction)

HALLUX VALGUS

The deformity of hallux valgus consists of extreme adduction of the proximal phalanx of the great toe towards the mid line of the foot and is associated especially in the most extreme forms with varying degrees of varus of the first metatarsal. Lesser degrees of lateral deviation are not uncommon as a result of the prevalent use of badly designed and ill fitting shoes even when the position of the metatarsal is normal.

The original deviation is progressively increased by the contracture and shortening of the adductor hallucis and extensor hallucis longus so that ultimately the base of the phalanx is displaced so far laterally that it articulates solely with the lateral condyle of the metatarsal head. The medial condyle of the metatarsal head remains as a prominence on the medial side of the foot and is subjected to friction and pressure from the shoe. An adventitious bursa is accordingly formed and a corn or callosity develops in the overlying skin. The projecting bone together with the bursa and corn or callosity are collectively known as a bunion.

PATHOLOGY

The tissues on the concave side of the deformity—capsule, muscle and ligaments—are adaptively shortened while the capsule and ligaments on the medial side of the joint are stretched. The cartilage on the exposed part of the metatarsal head undergoes fibrillation and

degeneration, and marginal osteophytes are thrown out as in osteoarthritis. The bursa is liable to inflammatory changes, and in its late stages the joint is osteoarthritic.

CLINICAL FEATURES

Many people with hallux valgus suffer relatively little trouble till osteoarthritis supervenes in later years. In others pain may arise in association with the corn or callosity or the bursa may become repeatedly or chronically enlarged or even suppurate. In these individuals pain is the result of pressure on the affected structures and relief is often obtained by cutting away the portion of the boot or shoe overlying the bunion. When the symptoms are due to arthritis the range of movement of the joint is both limited and painful. The condition is often accompanied by symptoms of foot strain or established flat foot.

TREATMENT

(a) Conservative Treatment

In mild cases the symptoms may be relieved by the provision of shoes of rational design with a straight inner side and an upper of soft leather which can be stretched in the region overlying the sensitive joint. The fitting of a bar to the sole of the shoe behind the metatarsal heads is a useful addition which decreases the trauma of weight bearing. In addition manual correction of the deformity should be practised in association with foot exercises designed to develop disused and atrophic muscles.

None of the devices for holding the toe in an improved position have any curative value nor do they relieve the symptoms.

If the symptoms are severe operation should be advised.

(b) Operative Treatment

Operation is indicated for the relief of symptoms alone and should not be undertaken merely for the æsthetic effect. It should not be undertaken in the presence of active bursitis.

Various types of operation are worthy of consideration.

(1) **The Conservative Operation** Removal of Exostoses and Bursa. This operation is indicated when the symptoms are due to pressure on the exostoses situated on the prominent metatarsal head and overlying bursa. It will not produce relief of symptoms in the presence of gross arthritic change or deformity.

An incision 2 to 3 inches long is made centred over the metatarsophalangeal joint on the dorsal medial aspect and curving towards the sole at the distal end immediately proximal to the interphalangeal joint. A similar incision is used for all hallux valgus operations. The U shaped incision is undesirable as the poor blood supply at the apex of the flap frequently causes delay in healing with the resulting broad tender scar. The bursa is dissected out and the medial half of the metatarsal head and any remaining exostoses removed with a sharp osteotome.

(2) Excision of the Proximal Half of the Phalanx (Keller)

This operation is recommended as the most satisfactory procedure in the large majority of cases and is especially useful in the presence of symptoms of arthritis. Through the same incision as that described above a U shaped flap of soft tissue is dissected up from the medial aspect of the metatarso phalangeal joint with its base close to the inter phalangeal joint. The proximal two thirds of the phalanx is denuded of soft tissue and the phalanx divided about half way between the head and the base and the proximal portion removed care being taken throughout the procedure to prevent injury to the underlying flexor tendon. The head of the metatarsal is reshaped by removal of the exostoses. The flap of soft tissue is then turned into the space between the phalanx and the metatarsal head and stitched over the raw surface of the phalanx. If the tendon of the extensor hallucis longus is contracted it is lengthened in the operative field or tenotomized at some distance above the site of operation.

At the termination of the operation a pad is placed between the first and second toes and the toe maintained by bandages in the over corrected position. On the fourth or fifth day the patient is encouraged to begin gentle active movements. Walking is permitted after an interval of about three weeks.

(3) The operation described on p. 772 for Hallux Rigidus is the one usually carried out by the author.

(4) Excision of the Head of the First Metatarsal This operation is in common use and has the advantage of correcting the gross deformity. It has however the grave disadvantage that it removes an important weight bearing point of the foot and thus should not be considered in a patient whose work involves prolonged standing or walking. Attempts to preserve the weight bearing portion of the metatarsal head by resection of the minimal amount of bone are frequently doomed to failure because successful arthroplasty depends on the resection of a considerable amount of bone.

The operation differs from that described above only in that instead of resection of the base of the phalanx the head of the metatarsal is removed.



FIG 358—Hallux Valgus. (a) Severe degree. (b) After arthroplasty and correction.

(5) *Osteotomy of the Metatarsal Neck* Jones and Lovett recommend a cuneiform osteotomy of the metatarsal neck and there are many operations of similar type described. These operations not only have the disadvantage of prolonged convalescence but are unsatisfactory because the base of the phalanx continues to articulate with the lateral condyle of the head of the metatarsal and the osteotomy does not correct this abnormal relationship.



FIG. 309—Hallux Valgus
Wedge osteotomy to correct deformity

After Treatment

When the patient becomes ambulatory he uses a soft shoe and is instructed in the correct heel and toe method of gait.

If the joint becomes hot and swollen the patient rests with the foot elevated until the condition becomes quiescent. Throughout ambulatory treatment he practices active toe and foot exercises. Passive movements are contra-indicated especially in a hot and swollen joint. It is essential following any of these operative procedures that the patient be provided with suitable shoes with a straight inner side which cannot cause recurrence of the deformity as a result of pressure. The frequently accompanying metatarsalgia and

pes planus should be treated by foot exercises designed to improve mobility and develop the muscles of the foot.

METATARSALGIA

Pain beneath the metatarsal shafts or heads is commonly known as metatarsalgia but it is important to discriminate between the different lesions which may give rise to it.

It has already been suggested that the anterior metatarsal arch at least in the weight-bearing foot does not exist but under certain circumstances the intermediate metatarsal heads may be overloaded and give rise to pain. Pain may also arise as a result of inflammatory affections—e.g. rheumatism in the metatarso-phalangeal joints or as a sequel to falls from a height on to the fore part of the foot.

Metatarsalgia therefore may be—

- Traumatic
- Inflammatory
- Static

The static variety demands most consideration. It is frequently found in association with developmental anomalies particularly metatarsus primus varus and metatarsus hypermobilis and commonly arises in those conditions where there is a rapid increase in the body weight or a debilitating illness which renders the foot muscles atonic.

The extra weight borne by the metatarsal heads throws a strain on the transverse ligaments of the metatarsal heads, and pain results, just as it does in longitudinal arch strain. This type of metatarsalgia is sometimes known as *relaxation metatarsalgia*.

When the metatarsal heads become crowded together as a result, for example of the wearing of narrow shoes, the digital nerves passing forward to the toes between the heads of the metatarsals are liable to compression or irritation. This in time produces an interstitial neuritis which may be productive of agonizing pain and is known as *compression metatarsalgia*.

There are thus two main varieties of *static metatarsalgia* viz (a) *Relaxation metatarsalgia*, due to overstretching of the plantar ligaments, (b) *Compression metatarsalgia*, due to nipping of the digital nerves. In addition, metatarsal pain is also a prominent feature of Kohler's disease and march foot.

CLINICAL FEATURES

In the first of the static types—the ligamentous—the pain is situated beneath the metatarsal heads and is of constant burning character and often described by the sufferer as like toothache. It may be relieved by lateral compression of the metatarsal heads which relieves the strain on the stretched ligaments. As it is so often a sign of overloading of the foot it may be associated with signs of foot strain related to the longitudinal arch. When the condition is acute there is not infrequently some oedema of the dorsum of the foot.

The foot is broader than normal—splay foot—and there are often obvious deficiencies between the metatarsal heads caused by atrophy of the interossei muscles. The clawing of the toes which occurs is further proof of the occurrence of muscular atrophy affecting the lumbricals and interossei, the proximal phalanges becoming dorsiflexed as a result of the poorly opposed contraction of the extensor muscles of the digits.

In the neuritic type the foot usually presents a different form, it is narrow, and the forefoot appears compressed. The pain in this type is usually paroxysmal in nature commencing beneath the metatarsal head and shooting forwards towards the tip of the toe. It may affect any or all of the digital nerves, but is most common in relation to the fourth metatarsal and fourth digit. The paroxysms may be so severe that the sufferer has to stop while walking and remove the shoe. In these cases the pain can sometimes be brought on, or accentuated, by side to side compression of the metatarsal heads, and is occasionally induced by removing the shoe.

TREATMENT

The object of the treatment must be to strengthen the muscles which support the forefoot, and to keep the forefoot in a corrected position while this is being accomplished. Any co existing defects in

the mechanics of the foot should be treated, especially longitudinal arch strain and shortened tendo calcaneus

The following measures may be employed

Support (a) In all types the fitting of a shoe of rational design is essential. It should have a straight inner side, a broad thick sole, a low heel and a metatarsal bar or crescent should be placed across the sole well behind the heads of the metatarsals. Occasionally the simple method will effect a cure.

(b) In more severe cases the support must be applied directly to the foot and this may be most simply effected by means of a felt pad and adhesive strapping changed at intervals of one week.

An oval pad of piano makers' felt with bevelled edges is placed under the metatarsal arch and secured immediately behind the metatarsal heads by adhesive strapping. In the splay foot, or ligamentous type, the strapping may be carried round the forefoot so that it produces slight compression but when the pain is of the compression type any further compression should be avoided and the strapping carried round the medial and lateral margins only. The first felt pad is about $\frac{3}{4}$ inch thick, but it is thickened each time the foot is re strapped until the symptoms

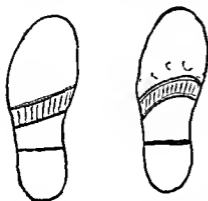


FIG 360—Types of metatarsal bars used in cases of metatarsalgia (After Lewin)

disappear. Some experiment may be required in order to determine the height of pad which produces complete relief of pain.

When the acute symptoms have been relieved regular exercises, especially those designed to develop the lumbricals and interosseous muscles should be practised.

(c) Certain patients require some permanent means of supporting the anterior arch.

A thin leather insole is cut so that it fits the shoe exactly. A resilient rubber pad of special shape is then securely fixed to the insole immediately behind the metatarsal heads. This method is of great value in chronic cases but its success depends entirely on the time and trouble taken to secure the correct position of the pad.

Operation In cases resisting all other forms of treatment the question of resection of the head and neck of the affected metatarsal bone may arise. The decision to resect the head and neck of a metatarsal should not however be made lightly, in view of the permanent residual disability in the form of weakness of the foot which may result.

When operation is considered to be essential it is performed through a straight dorsal incision over the affected metatarsal, care being taken

to see that no spicule of bone remains. The extensor tendon is transplanted into an adjacent one to prevent an undue pull on the unsupported toe. At the termination of the operation the foot is put up in a light plaster case moulded to the transverse arch but permitting plantar flexion at the metatarso phalangeal joints.

Walking is permitted after an interval of three weeks with the type of support described under (b) or (c) above and shoes of sound design fitted.

Forbes has suggested the transplantation of the long extensor tendon into the head of the affected metatarsal bone in the hope that it will sustain the head of the metatarsal and preserve it as a component of the anterior arch. The phalanx when released from the pull of the long extensor, resumes a normal position and is held there by the short extensor tendon, which is sufficient to maintain its position of equilibrium midway between flexion and extension.

In some cases good results are obtained without the disadvantage of removing the metatarsal head by dividing the digital nerves. McElvenney has described the presence of a tumour on the lateral branch of the median plantar nerve. The tumour can be found high in the web between the third and fourth toes and is easily excised through a web splitting approach with good results.

MARCH FOOT OR MARCH FRACTURE

This error is also a sequel to a developmental anomaly of the fore foot. Deutschlander in 1925 reported a series of 6 cases of localized sub periosteal deposits of osteoid tissue on the shaft of one or other of the second, third or fourth metatarsal bones and concluded, since a history of trauma was not forthcoming, that the condition resulted from infection by a low grade virulent organism. He failed to recognize its relationship to the marching fracture of soldiers described about seventy years previously by Breithaupt.

CLINICAL FEATURES

The condition may begin insidiously being obvious first as a puffy oedema of the forefoot when the foot is subjected to abnormal use—as in long marching or *hiking*. Sometimes the condition is associated with pain from the beginning though occasionally, the only complaint is of an indefinite ache and feeling of fullness across the dorsum of the foot, but if the sufferer continues to indulge in unwonted exercise the oedema increases and the pain becomes more severe. X ray examination in the early stages shows no change in the bone but in the course of time, if repeated examinations are made there will become apparent a cuff of new sub periosteal bone around the neck or adjacent part of the shaft of one or more of the metatarsals. If the exercise to

which the foot is subjected is extreme, and if there occurs in addition a minor trauma—e g stepping on a pebble—the metatarsal may fracture at the site of the osteoma, the fracture in this event being a pathological one, following the abstraction of calcium from the bone and its deposit in the osteoma, and associated with extreme pain and gross œdema

This condition is encountered most frequently in the second metatarsal, but may occur in the third or fourth metatarsal and is not infrequently bilateral

ETIOLOGY

It was Deutschlander's view that the condition resulted from a low-grade, blood borne infection. There is no evidence to confirm this opinion.

Jansen suggested that the condition was caused by the spasm of the interosseal muscles, through which the vessels entering and leaving the metatarsal bone penetrate which led to vascular obstruction, and consequent œdema of the soft tissues and periosteum, the periosteum became thick and spongy and the œdema resulted in rarefaction of the bone which was then rendered brittle.

Kirschner believes that the fracture is the primary disturbance. It is now generally accepted, however, that the primary factor is a developmental anomaly leading to a mechanical insufficiency of the first metatarsal and that the most important anomaly in this respect is metatarsus atavicus. In this condition the longer second metatarsal must assume the rôle of the first in providing a fulcrum for the take off in walking which it may do quite efficiently in ordinary circumstances.

If, however, this foot of structurally weak type is suddenly subjected to the trauma of long marches, or to sudden change of employment demanding long hours of standing, the constant strain results in sub periosteal œdema with the withdrawal of calcium from the adjacent cortex and a slowly increasing deposit of osteoid tissue around the bone, a slight trauma is then sufficient to complete the picture by producing a fracture. The pathology of the condition is thus similar to myositis ossificans or the traumatic osteoma which may follow a blow on the thigh.

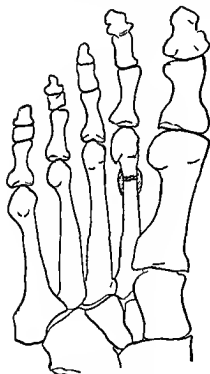


FIG 361—A March Fracture

TREATMENT

In the acute stage relief from weight-bearing is secured by the application of a walking plaster from the toes to the knee. This plaster should be retained for a period of three to six weeks depending on the age of development at which the case is first seen. When the plaster is removed a course of progressive active exercises is essential. In cases seen at a late stage and with minimal symptoms the application of a metatarsal bar to the sole of the shoe in the position described previously and institution of foot exercises may constitute all the treatment required. When the osteoid tissue is fully consolidated the swelling disappears and the thickening of the metatarsal which results from it is capable of additional weight bearing strain.

KÖHLER'S DISEASE OF THE METATARSAL HEAD
FREIBERG'S INFRACTION

In this condition there is great broadening of the metatarsal head, stiffness and pain at the metatarso phalangeal joint.

X RAY PATHOLOGY

The sequence of changes occurring in this disease can be studied radiologically. The earliest change is a slight subcapital osteoporosis, the porotic area being situated always in relation to the dorsal aspect of the articular surface and the toe is usually clawed, i.e. the base of the phalanx is opposite the porotic area. The next stage is associated with increasing size of the rarefied area and indentation or collapse of the articular surface which has now lost its normal trabecular pattern. Later the depressed area may become free from its parent bone and lie detached in the joint space as a loose body. The histological changes are characteristic. The osseous trabeculae become progressively thinned out and replaced by granulation tissue.

ETIOLOGY

Köhler regarded the changes as inflammatory in nature and thought the disease affected the epiphysis of the metatarsal head. He thus compared the condition with other epiphyseal lesions such as Perthes' disease and Osgood Schlatter's disease. Freiberg on the other hand interpreted the process in terms of trauma and supposed the primary lesion to be a traumatic fracture or infraction of the articular surface. There is no doubt however that the error is associated with developmental anomalies which overload the middle group of the metatarsals, the dorsiflexed posture assumed by the toes as a result of the atrophy of the interossei and lumbricals has the effect of concentrating the stress of injury, single and definitive or long standing as in the use of short shoes, to the dorsal area of the articular surface.

There is often considerable thickening of the metatarsal shaft—a compensatory phenomenon designed to reinforce the second metatarsal for its undue proportion of functional stress

CLINICAL FEATURES

The condition may arise at any age, and as it is not confined to the period before the epiphysis is fused, Kohler's original conception is wrong

In its acute phase while the articular surface is collapsing, there

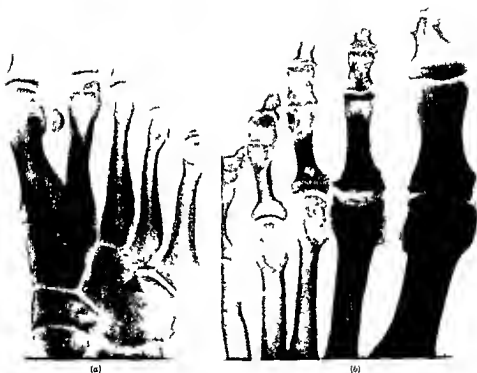


FIG. 362—Kohler's Disease of the Second Metatarsal Head

is extreme pain in the foot movements are painful, and there may be considerable œdema of the forefoot, especially marked on the dorsum. Later, when the collapse is complete, the pain may subside, leaving a deformed joint which is also less capable of free mobility than before.

The *X ray changes* are characteristic

- 1 There is broadening of the metatarsal head
- 2 The head is irregular in contour and flat
- 3 The joint space is increased
- 4 The shaft of the metatarsal is thick
- 5 Detached portions of the articular surface may lie free in the joint

TREATMENT

In the acute stages the application of a walking plaster cast will afford relief. In mild cases the use of a metatarsal bar or pad may be all that is necessary.

If stiffness or pain persist when the cycle of pathology is complete, relief may be obtained by re-shaping the head of the affected metatarsal to its normal shape, and this operation is preferred to excision of the head, which although it is more certain of relieving the immediate symptoms may have the disadvantage of weakening the transverse arch.

HALLUX RIGIDUS

Hallux rigidus is a condition of stiffness of the metatarso phalangeal joint of the great toe, especially characterized by absence of dorsiflexion. In early cases, the power of plantar flexion is present but in extreme examples all movement of the joint is abolished, and a flexed position is gradually assumed—*hallux flexus*.

Rigidity of the joint may either be associated with inflammatory changes such as rheumatism, or else be a symptom of a traumatic lesion, in which case the causal lesion is a stroke or blow in the long axis of the toe, such as may be got from kicking a hard object giving rise to contusion of the opposing cartilaginous surfaces of the joint and an intra articular effusion. The limitation of movement in the first instance is the result of muscular spasm designed to prevent movement at the painful joint, but secondary accommodative changes in the capsule and anterior ligaments render the stiffness permanent.

In the *static* variety of hallux rigidus, there is a concomitant flat foot. In the normal foot, the long axis of the first metatarsal is directed downwards and forwards from the summit of the arch, but when the arch is depressed, the base of the metatarsal sinks, its long axis becomes horizontally disposed and, in consequence the head of the bone is rotated upwards and the dorsal portion of the articular surface ceases to be articular. The exposed area undergoes the usual changes of disuse—fibrillation and osteophytic outgrowth—so that any attempt to move the base of the phalanx over this degenerate surface is painful. Reflex spasm of the muscles ensues to prevent this, and the metatarso phalangeal joint is kept rigid.

In both varieties, the rigid joint in its later stages becomes the site of characteristic osteo arthritic changes.

CLINICAL FEATURES

In hallux rigidus, pain is particularly experienced on walking, and especially when attempts are made to dorsiflex the joint for the "take-off", the pain is less severe on standing, unless there is severe flat foot. The joint is sometimes swollen from peri arthritis, while a characteristic feature is the occurrence of a small marginal exostosis on

the dorsal edge of the articular surface of the metatarsal head—i.e. at the degenerate area of the cartilage. The gait is shuffling and ungainly.

In the early cases, before the rigidity is absolute, attempts to move the joint cause great pain, but later, when the stiffness is permanent, ordinary passive attempts at motion are painless, and the condition may be masked by an abnormal degree of dorsiflexion acquired by the interphalangeal joint.

TREATMENT

Conservative In moderate degrees of this condition relief may be obtained from restricting the movement of the joint (a) by thickening the sole of the shoe, (b) by the insertion of a thin plate of tempered



FIG. 363.—Bilateral hallux rigidus on double Braun Splint showing Method of obtaining separation of the Joint Surfaces by means of pulp traction.

steel between the two layers of the sole or (c) by the fitting of a metatarsal bar to the sole of the shoe.

In acute cases with a short history and in young people a cure may sometimes be effected by over correction of the deformity under anaesthesia and the application of a walking plaster case to maintain the toe in dorsiflexion. The plaster case should be retained for four to six weeks.

Operative The large majority of cases eventually require operative interference. An incision 2 or 3 inches long is made centred over the metatarsophalangeal joint on the dorsal medial aspect and carried directly down to the head of the metatarsal capsule of the joint and the proximal half of the phalanx just medial to the extensor tendon. Curved periosteal elevators are passed round the phalanx from the

medial and lateral sides and the phalanx cleanly divided at its central point with a sharp osteotome care being taken to protect the flexor tendon from injury. The proximal half of the phalanx is then excised and any exostosis which exists on the metatarsal head is removed. The capsule and skin incision are then closed, no soft tissue being interposed between the cut phalanx and the metatarsal head.

At the termination of the operation a stainless steel traction pin is inserted through the pulp of the terminal phalanx.

After Treatment The limb is placed on a Braun splint with a protection loop situated directly over the toes. Weight traction of a few ounces just sufficient to keep the joint surfaces apart is applied to the pulp traction pin and the direction of pull is arranged so that the toe is maintained in slight dorsiflexion. A similar effect is got by applying the traction directly on to a plaster-of-Paris foot case as in



FIG. 364.—Traction applied by means of a Plaster of Paris Case

the accompanying diagram. Silk worm gut is looped through the ring of the pulp traction loop and knotted over the plaster extension. Rotation of the toe can be corrected by this method of fixing the traction and more freedom is got in bed. On the second or third day the patient is encouraged to attempt active movement of the toe. The traction is maintained for about 14 days and thereafter the Braun splint is unnecessary. The patient remains in bed for 3 weeks (see Fig. 363).

Before the patient resumes ambulation it is important that he be re-educated in walking so that he heel and toes rather than resumes his old habit of walking on the outer side of the foot which was necessary previous to operation. Unless this essential re-education is carried out the patient will naturally resume his previous habits and the regained metatarsophalangeal mobility will be lost.

The return of full weight bearing activity is carefully graded and no attempt made to increase activity too rapidly. If the joint becomes

hot and swollen the patient should return to bed and practice active non weight bearing exercises until the local temperature and swelling have subsided. The continuation of weight bearing activity on a hot and swollen joint merely results in excessive fibrosis and consequent loss of mobility.

The best results are to be expected in unilateral cases with a history of trauma.

In bilateral cases of long standing and with co existing pes planus the prognosis is less good and in order to obtain the optimum results attention must be directed towards treatment of the pes planus in addition to the condition at the first metatarsophalangeal joint.

PAINFUL CONDITIONS OF THE HEEL

Pain in the heel frequently occurs in persons who stand or walk a great deal—hence the term *policeman's heel*—but may also arise from other causes. Whatever the origin the pain is usually aggravated by use and may be entirely absent during rest. The painful area can always be found by digital pressure.

The causes of this painful condition may be classified as follows:

- 1 Traumatic disturbances
- 2 Pathological disturbances
- 3 Static disturbances

1 Traumatic Disturbances

The Effect of Trauma. Pain resulting from trauma may be situated at the back of the heel around the insertion of the tendo calcaneus or on the plantar aspect.

When situated in the region of the tendo calcaneus the underlying conditions are—tenosynovitis of the tendon sheath the formation and irritation of enlarged burse and partial tears of the tendon. In all cases the pain is rendered worse by movement and may even be completely relieved by rest. In *tenosynovitis* of the tendo calcaneus there is swelling from effusion often accompanied by fine crepitus and when the condition is chronic there may be an actual deposit of fibrous tissue in and around the tendon giving it an irregular form on palpation. When these fibrous deposits project backwards the wearing of a boot is likely to entail discomfort.

Bursal enlargements may affect the bursa normally situated between the tendon and the calcaneus or a subcutaneous adventitious bursa which occasionally develops over the most prominent part of the posterior surface of the bone. Roth drew attention to the fact that this surface is often not flat but irregular being more prominent on its lateral side at the lowest margin of the insertion of the tendon. He found that in 39 per cent of cases of pain in the heel this prominence is marked and palpable as a tender hard lump though as a general

rule an X ray examination does not reveal it. It is in this situation that the adventitious bursa forms.

The bursa at the insertion of the tendo calcaneus is liable to inflammation from friction produced by an ill fitting boot and as a result of that there is a localized tenderness at the site of the bursa and occasionally a small area of fluctuation can be detected by lateral palpation anterior to the tendo calcaneus.

When the adventitious bursa is enlarged the swelling is situated lower down and is usually larger. Fluctuation is easily elicited and the skin overlying the swelling is often red and oedematous.

Partial tears of the tendon result from forcible contraction of the tendon or from overstretching and the lesion so produced may consist of avulsion of a few of the tendinous fibres from the bone or of actual rupture of some of the fibres immediately above their insertion. In the first case the disturbance of the periosteum results in periostitis with relatively little or no swelling but tenderness at the insertion of the tendon and exquisitely painful movements. Partial rupture of the tendon fibres may be associated in the acute phase with slight swelling from effusion of blood and later with the formation of irregular masses of fibrous tissue in the tendon.

TREATMENT

In all these cases rest is essential. In partial ruptures when the pain is not severe it may be sufficient to raise the height of the heel of the shoe from half to three quarters of an inch to prevent any overstretching of the tendon. Bands of adhesive plaster over the tendon above and below the malleolus are useful adjuvants.

In the case of a persistent periostitis it may be necessary to erase the affected periosteum.

Roth deprecates operation in cases of prominent heel bone believing that the symptoms produced by it may be obviated by beating out the lateral half of the counter of the shoe at the back of the heel to accommodate the enlargement.

In *acute bursitis* relief may be obtained by rest from movement and by fomenting. In subacute and chronic cases the bursa may be raised above the level of the shoe by the use of a sponge rubber heel inside. In cases where relief of friction does not lead to resolution the bursa may be excised.

Pain on the *plantar aspect of the heel* is due to the formation of *calcanean spurs* or to traumatic or inflammatory *fibrositis* at the insertion of the plantar fascia without spur formation.

(a) Plantar Fibrositis

Pain may arise at the insertion of the plantar fascia in association with focal sepsis, metabolic disturbances such as gout or rheumatism.

(b) Calcanean Spurs

The occurrence of a spike of bone at the anterior edge of the calcanean tuberosities—usually the medial—is known as a calcanean spur.

It may be a sequel to repeated attacks of plantar fasciitis, or result from trauma. In the former case, the repeated hyperæmia leads to the abstraction of calcium from the calcaneus, and, the granulation tissue produced by the inflammatory reaction constituting an ossifiable medium as the hyperæmia resolves, the available calcium is deposited in it to produce the spur. It is possible that the constant pull of a shortened plantar fascia—or traumatic separation of slips of the fascia or the constant trauma of ill fitting footwear—may also produce the spur in a similar way i.e. by inducing hyperæmia, but it is also suggested that these factors operate by causing tiny detachments of the periosteum at the insertion of the fascia, and in consequence, small sub periosteal deposits of new bone.

CLINICAL FEATURES

It is generally believed that since the formation of a calcanean spur is secondary to fibrositis or traumatic detachments of the plantar fascia it does not give rise to symptoms *per se*, and that pain, when present is due to the causative condition and not to the spur.

The characteristic features are pain in the ball of the heel, especially marked on long standing or walking, tenderness on the plantar aspect of the heel and most marked at the attachment of the plantar fascia to the medial tubercle of the calcaneus and occasionally slight swelling at the attachment of the fascia.

X ray examination may or may not reveal the presence of a spur.

TREATMENT

Non Operative Treatment Any obvious cause such as gonococcal infection or infected tonsils or teeth, must be dealt with, and it is wise to attend to the condition of the gastro intestinal tract. If the pain is acute the patient should be kept in bed and fomentations applied. After the pain and tenderness have disappeared, proper shoes should be ordered and felt or sponge rubber pads inserted to relieve weight-bearing on painful areas. A low rubber heel should be substituted for the heel of the shoe.

Many cases are relieved by adding $\frac{1}{2}$ inch to the height of the heel thus prevents the pull of the plantar fascia on the inflamed area.

In some cases considerable relief may be afforded by the use of radiant heat or diathermy.

Operative treatment may be undertaken in resistant cases, and the spur, when present removed, some observers think this unwise since they hold that the spur is never the cause of the symptoms *per se*. It is certain that if it is to be undertaken, the operation should be postponed till the infective or toxic agent producing the fascial disturbance is quieted, for if operation is undertaken in the actively painful stage of the disease, the hyperæmia following the operation may lead to further spur formation.

The operation is performed through an incision along the medial border of the foot the spur being removed by means of an osteotome.

(c) Traumatic Sub taloid Arthritis

Fractures of the heel bone are usually caused by a fall on the feet from a height and as they may not produce any gross deformity at the time are liable to be overlooked unless the most careful X ray examination is carried out. These undetected fractures may ultimately give rise to a very troublesome painfulness and weakness of the foot which may constitute a grave and lasting disability for a working man. The pain and weakness are due to a chronic sub taloid arthritis for which the only treatment that is likely to be of any benefit is a fusion of the joint. The operation for this is described on page 816.

2 Painful Heel due to Pathological Disturbances

Apart from trauma pain in the heel may have its origin in organic disease of the bone or epiphysis and the infection may be tuberculous syphilitic or pyogenic or may follow a general gonococcal or rheumatic toxæmia.

(a) Epiphysitis of the Calcaneus

This condition is described in the chapter on Diseases of the Epiphyses. It usually occurs in boys between the ages of 9 and 13 and in the differential diagnosis various conditions have to be borne in mind.

(1) *Calcanean bursitis*. In this condition the inflammation is more superficial and localized. The X ray bone picture is negative.

(2) *Teno synovitis* of the tendo calcaneus is characterized by pain referred to the tendon and by palpable silky crepitus on movement. X ray examination is again negative.

(3) *Bursitis* between the calcanean tendon and the skin is a superficial inflammation usually the result of pressure from the shoe and is readily recognized.

(4) *Calcanean Spurs*. These are rare in early adolescence and are usually found on the infero medial aspect of the calcaneus. The area of sensitiveness suggests the diagnosis which should be confirmed by X ray examination.

(b) Tuberculosis of the Calcaneus

This is usually situated in the anterior rather than the posterior region of the bone. An X ray photograph materially aids differential diagnosis and shows a degree of bone atrophy that is not found in epiphysitis.

(c) Pyogenic Infection

This produces marked inflammatory reaction with destruction of bone.

3 Static Disturbances

Pain on the inferior surface of the heel with sensitiveness to pressure on standing may be caused by a variety of static disturbances.

If the condition is unilateral it is frequently caused by standing

too long on one foot, e.g. where limbs differ in length. In a *cavus* deformity of the foot, the posterior part of the calcaneus may be very painful, due to the fact that the bone is much more perpendicular than usual and acts less as a resilient support for the arch of the foot, and more as a direct continuation of the leg bone. The pain also occurs from prolonged standing, and, accordingly, is common in police men and nurses. It is often found associated with a weak, flat foot.

TREATMENT

Pain localized in the heel is easy to treat if there is some obvious cause but where this is not so the outlook is not so happy. X-ray examination may reveal more or less well marked spurring under the calcaneus. *definite foot deformity talipes calcaneus or cavus*, pain in the heel being due to the more vertical position of the calcaneus. Treatment consists in correction of the deformity. There are other cases again chiefly young patients, where no morbid condition can be found and though certain of these are probably neurotic in origin others may be due to *foot strain or fibrositis*, X-ray evidence being negative. If rest followed by the use of cork soles, cupped over the tender area does not cure the condition, the origin of the plantar fascia and short muscles may be separated from the under surface of the calcaneus as in the Steindler operation for a claw foot.

CLAW FOOT

The term *claw foot* or *pes cavus*, is applied to a deformity in which clawing of the toes is combined with a raising of the long arch of the foot and which may arise either as a congenital or as an acquired deformity.

If congenital it does not usually become apparent until the child is six or seven years old. About half the cases of congenital claw foot are associated with a *spina bifida occulta* while Beykirch believes that the majority of the remainder occur as the result of developmental aberration involving the spinal cord—a *myelo-dysplasia*.

Jones and Lovett divide the acquired type into four groups

1 **Claw Foot in Infantile Paralysis** Claw foot frequently occurs after a preceding attack of *poliomyelitis*, more especially where the *peroneus* is almost negligible, and it is, in fact, frequently a characteristic deformity of the so called "sound leg." Duchenne suggested that it was due to paralysis of the *interossei* and the *lumbricals* thus bringing it into line with the "main en griffe" of ulnar paralysis.

2 **Claw Foot in Progressive Lesions of the Central Nervous System** Claw foot, usually bilateral, is a well known clinical accompaniment of *Friedreich's ataxia*, of the *peroneal* type of muscular atrophy, and of other rare affections of the central nervous system.

3 Claw Foot following Inflammatory Infections The deformity may be a sequel to inflammatory contracture of the soft tissues of the sole of the foot

4 Idiopathic Claw Foot This is the most common and most important type. It has been customary to regard as the primary factor shortening of the tendo calcaneus despite the fact that this is never present clinically and as Todd recently pointed out contracture of the tendo calcaneus is followed by a most severe type of flat foot—*valgus ex equino*. It has also been suggested that the use of footwear which is too short may cause the deformity although this is probably no more than an aggravating factor. Paralysis of the interossei and lumbricals has also been blamed and the condition likened in con-



FIG. 365.—Claw foot of Third Degree with marked Deformity of Toes

sequence to the *main en griffe* deformity of ulnar nerve palsy. Todd strongly asserts that since this atrophy has never been demonstrated at operation and since no cause has been assigned to it it need not be seriously entertained. This observer in an authoritative paper has shown that the deformity of pes cavus consists first of all in a dropping or flexion deformity of the forefoot the result of slight relative weakness of the extensor muscles which is followed by—



FIG. 366.—The plantar aspect of a Claw foot

(1) *Contracture of the plantar fascia and adaptive changes in the plantar structures*

(2) *Clawing of the toes* This results from the dropping of the metatarsal heads below their normal level and the alteration of their line of action which leads to the pulling up of the proximal interphalangeal joints of the

toes and has the secondary and important effect of shortening the course of the weakened extensors so that they adaptively contract and may in this way mask their original weakness

When the extensor digitorum communis is mostly affected but the extensor hallucis proprius is normal there is in addition to the pes cavus some adduction of the forefoot from the beginning. Even when this is not so an element of adduction and inversion appears in the late stage of the process as well as some secondary contracture of the tendo calcaneus

CLINICAL FEATURES

Great stress was formerly laid on the conventional division of the

clinical features of claw foot into a series of stages, but it is important to recall that the deformity is a progressive one

First Degree Claw Foot At this stage the complaint is that the child is clumsy, and that when running about he frequently falls without apparent cause, or catches his toes against low objects such as the edge of a carpet. Formerly attributed to contracture of the tendo-calcaneus it has been shown by Todd that the only evidence at this stage is a slight extensor weakness which may be evidenced by inability to pull up the toes, or by slight difference in the diameter of the two limbs. The tendo calcaneus is not shortened, and if the forefoot is covered, the posterior part of the foot looks normal, i.e. there is no equinus

Second Degree Claw Foot At this stage, in addition to the slight flexion of the forefoot there is dorsiflexion of the great toe at the metatarso phalangeal, and flexion at the interphalangeal joint. The plantar fascia is felt to be tense and contracted, and there is visible deformity. A characteristic of the deformity at this stage is that the clawing can be made to disappear by upward pressure on the ball of the great toe, showing that it is caused by a downward dropping of the metatarsal head. While a child may not complain of any pain an older patient is apt to suffer some discomfort after prolonged walking

Third Degree Claw Foot In the third stage, the arch of the foot is markedly raised, and all the toes are fixed in flexion, while the tendo calcaneus may begin to appear contracted. The plantar structures are further shortened and all the toes now dorsiflexed at the metatarso phalangeal joints and flexed at the interphalangeal joints. These deformities are becoming rigid and it is no longer possible to correct the deformity by finger pressure under the first metatarsal head. The chief complaint may be of painful corns which form on the dorsum of the flexed interphalangeal joints or on the points of the toes, but in addition, such a foot is one which tires easily after much standing or walking, and a marked degree of claw foot is a greater handicap than a corresponding degree of flatness, should the patient wish to join a Service

Fourth Degree Claw Foot In the fourth stage, in addition to the cavus and the hammered toes, there is adduction at the tarso metatarsal joints resulting in a kind of varus deformity. The foot is now rigid and painful, tender callosities are present on the outside, and walking is becoming increasingly painful and difficult

Fifth Degree Claw Foot. The fifth stage is seen only in cases following some paralytic condition. The toes are blue and cold, the whole foot is contracted into a rigid equino varus, with a high arch and hammered toes. The patient is in a most disabled condition and exquisitely tender callosities are present

TREATMENT

First Degree

The treatment consists of the use of a shoe with a $\frac{1}{2}$ inch thick metatarsal bar placed across the sole immediately behind the heads of the metatarsal bones

Second Degree

A shoe fitted with a metatarsal bar may give temporary relief but adequate treatment of this stage is by operation

The plantar fascia is divided subcutaneously and the tendon of the extensor proprius hallucis divided at its insertion and passed through the neck of the first metatarsal. After the tenotomy the foot is

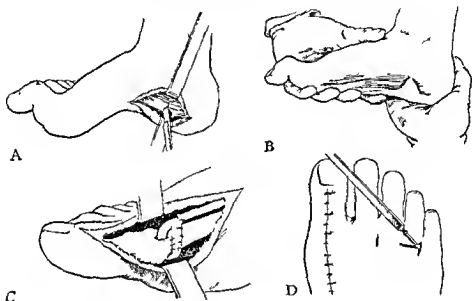


FIG. 167.—The Treatment of a moderate degree of Claw Foot by Tenotomy and Tendon Transplantation

wrenched. A plaster of Paris cast is then applied to the foot to maintain the corrected position for a period of three or four weeks. Afterwards a metatarsal bar is affixed to the shoe.

Third Degree

Treatment of third degree claw foot is on the same lines as in second degree but it is of necessity more thorough more extensive and more drastic.

Steindler recommends that in the first place all the structures on the sole of the foot which arise from or are attached to the under surface of the calcaneus be separated from that bone through an incision on the medial or lateral side of the heel. Steindler actually makes a horse shoe flap right round the heel through which he dissects off the plantar fascia and muscles from the calcaneus but the majority of surgeons use a single medial incision. The structures are crased right

forward to the calcaneo cuboid joint on the lateral side, and to the talo navicular on the medial side where they take up a new attachment, the procedure is thus a "muscle slide" operation. The extensor tendons of the toes, which may lead to a relapse, may now be divided. Todd believes that Steindler's method does not lead to sufficient correction, and he has accordingly devised a more drastic procedure of his own.

Todd's Operation A tourniquet is applied to the limb, a curved incision is then made from the front of the calcaneus forwards to the base of the great toe, and care is taken to carry the central part of the incision as high as the tubercle of the scaphoid. The incision is deepened to expose the upper border of the abductor hallucis, which is then stripped from the plantar surface of the tarsus, and detached posteriorly from its origin into the calcaneus. In carrying out this step it is important to avoid damage to its blood and nerve supply which enter the muscle about 1 inch in front of its posterior attachment. The medial intermuscular septum is divided, and the sheath of the flexores digitorum longi and hallucis longus, and all the attachments of the tibialis posterior save that to the navicular, similarly dealt with.

The cuneo metatarsal, the naviculo cuneiform, and the talo navicular joints are now opened by division of the capsule and ligaments in the dorsal medial and plantar aspects, and if necessary the spring ligament is cut. Next, the knee is flexed and the foot laid with its medial side on a sandbag and a Steindler's muscle slide performed through a short horizontal incision on the lateral side of the heel bone.

The foot is now manipulated upwards and laterally into an exaggerated valgus position.

In some cases it may be found wise to transplant each extensor tendon through the neck of the corresponding metatarsal so as to raise the front part of the foot and lift the dropped anterior part of the arch. If full correction cannot be obtained thus, $\frac{1}{2}$ to 1 inch of the shaft of the first, second, third and fourth metatarsals should be removed through separate incisions on the dorsum of the foot. Lastly, to complete the correction, the tendo calcaneus may be lengthened by open operation. The foot is then put up in plaster of Paris for five weeks and thereafter the treatment follows the lines already described.

Lambrinudi's Operation Lambrinudi has found that correction of the clawing of the toes not only causes considerable improvement of the deformity and therefore reduction of symptoms from corns and callosities, but a marked improvement of the general function of the foot. The principle underlying the operation he has devised is that by arthrodesis of the inter phalangeal joints the long flexor muscles take up the function of the lumbricals and flex the toes at the metatarsophalangeal joints.

Through lateral incisions along the dorsum of the toes the interphalangeal joints are exposed and their opposing surfaces excised. Arthrodesis may be achieved either by relying on simple apposition of the apposed cut surfaces or may be assisted by a small bone graft which hastens union as well as ensuring apposition. In some cases the union may be got by carrying out the spike operation (*vide p 786*). The extensor tendons of the second, third, fourth and fifth toes are tenotomised and also the dorsal part of the capsule of the metatarso phalangeal joint. In some cases Lambourn advises that the extensor tendons be transplanted into their own metatarsal necks though this is usually unnecessary since the flexor tendon in the presence of a single finger of bone to the toe acts as a sling to the metatarsal heads and holds them up. Interference with the fifth toe may be unnecessary but if the deformity is gross the toe is amputated. Before closing the dorsal incisions on the second, third and fourth toes a strong silk worm gut suture is passed from the flexor aspect of the toe round the proximal phalanx and out on to the plantar aspect close to the point of insertion. Lambourn uses a special sole plate to which these sutures are tied thus maintaining the corrected position at the metatarso phalangeal joints. The sutures however may be tied to a section of Cramer wire attached to a light plaster case enclosing the foot and leg. The advantage of the silkworm gut sutures round the phalanges is maintenance of the correction without pressure on the skin or interference with the circulation of the toes. The sole plate or plaster case and anchoring sutures are retained for 5 to 6 weeks by which time the ankylosis is firm and graduated exercises may be commenced. The procedure is tedious and time consuming but the author has been impressed by the results of the cases treated by this operation.

Fourth Degree

In the fourth stage the high crooked arch can usually be corrected only by dividing the bones across at the level of the mid tarsal joint. A simple transverse division of the tarsus is seldom sufficient and a wedge of bone has to be removed with its base at the dorsum of the foot and including a considerable portion of the head and neck of the talus. If the deformity is very rigid, with marked bony deformation a reconstruction operation such as that devised by Naughton Dunn may be advisable.

Fifth Degree

Amputation of the foot is often considered to be the treatment of choice but by means of a conservative operation a very useful foot can often be obtained and one which will serve the patient better than an amputation stump which, at this stage, is invariably ill adapted for wearing an artificial foot.

The talus is first removed by the usual curved incision underneath the lateral malleolus. The toes with the heads of all the metatarsal bones are then removed through dorsal and plantar rectangular flaps and the stumps covered over by the flaps.

SHORTENING OF THE TENDO CALCANEUS

Slight degrees of contracture of the tendo calcaneus are normal in many people, women, for example, who wear high heels often show it. In most cases it is not a source of discomfort, but where there are other evidences of foot strain the shortening of this tendon should not be overlooked. Shortening may also be due to reflex spasm when the mechanics of the foot have been disturbed, and is in this case *similar to the peroneal spasm which occurs in other cases*.

When it is due to reflex irritation, the mechanical errors which cause it should be corrected, if there is actual structural shortening some form of stretching must be undertaken.

Where the contracture is slight this may be carried out simply by removing the heel of the boot or by adding a metatarsal bar across the front of the sole both of which increase the pull on the tendon. The shortening may also be abolished by manipulation, repeated several times although this is accompanied by some pain and discomfort in the calf muscles.

Where the shortening is considerable it may be necessary to apply a plaster case to the foot and leg with the knee in acute flexion, and thereafter to extend the knee the tension thus placed on the gastrocnemius stretching the tendon.

Occasionally the tendo calcaneus has to be lengthened by open operation (see Polomyelitis). In this event the greatest care is necessary to avoid overlengthening, as such an eventuality may result in a weak foot or entirely upset the balance of the foot, and produce an inelastic springless gait.

HAMMER TOE

The deformity of hammer toe consists of dorsiflexion of the proximal phalanx, plantar flexion of the second, and flexion or extension of the distal. It affects usually the second toe, though slighter degrees are not uncommon in the other toes. The head of the first phalanx is subjected to pressure by the toe cap of the shoe, and frequently shows a painful corn beneath which a bursa forms over the interphalangeal joint and often becomes inflamed or even suppurates. The tip of the toe is pressed against the sole of the boot, and a corn may also develop at this point, and make walking difficult or impossible. The compression by the adjoining toes and by the sole of the boot produces a broadening and flattening of the tip of the terminal phalanx.

The condition is usually bilateral, and though in some cases it is congenital and may even be hereditary, it is most commonly caused by crowding of the toes into ill fitting and badly designed boots. It is therefore commonly associated with hallux valgus the displacement of the great toe forcing the second toe, which is the longest, into a



FIG 368.—Method of correcting a Hammer Toe with Plaster Strapping

flexed position. The condition usually begins in childhood when the growth of the toes is rapid and when they are apt to be subjected to pressure by too small shoes or socks.

The patient usually complains of a painful corn and bunion and it is for this that treatment is sought rather than for the actual deformity.

TREATMENT

The chief obstacles to reduction are the contracted ligaments.

In young children the distortion may be overcome by repeated manipulation the corrected position being maintained by strips of adhesive plaster passing over and under the affected toe and its neighbours. The use of a digitated stocking and of wide boots is also beneficial.

In adults operation is indicated in order that recovery may be certain and quick. Amputation should never be carried out in view of the likelihood of a hallux valgus supervening—or if already present becoming more severe.

The Operation. A semilunar incision is made transversely over the dorsum of the affected joint and the corn and bursa are excised along with the ellipse of skin. A transverse incision is made across the capsule and tendinous expansion at the joint line. The point of the scalpel is now passed in on either side of the head of the proximal phalanx and the medial and lateral collateral ligaments divided. The blade should be kept parallel to the phalanx and great care taken not to divide the digital arteries. Following division of these tiny ligaments

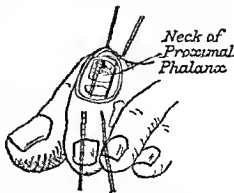


FIG 369.—Hammer Toe. Operation of excision of the Head of the Proximal Phalanx

access to both the head of the proximal phalanx and the base of the middle phalanx is excellent

One of two procedures may now be adopted

(1) The simplest operation which can be carried out consists merely of excision of sufficient of the head and neck of the proximal phalanx to allow of correction of the deformity together with removal of the cartilage from the base of the middle phalanx. Maintenance of correction of the deformity may be secured by catgut suture which is threaded through holes made in the shafts by means of a towel clip and which ensures that the opposing surfaces are in the closest apposition

(2) Alternately the spike operation may be performed. The head of the proximal phalanx is shaped to a point with the aid of a small pair of nibbling forceps. It is usually unnecessary to reduce the length of the proximal phalanx. The bony point on the proximal phalanx is now inserted into the hole in the base of the middle phalanx thus correcting the deformity.

In both operations it may be necessary to tenotomize the structures on the dorsal aspect of the metatarso phalangeal joint to ensure correction of the dorsiflexion of the proximal joint

INGROWING TOE NAIL

(Onycho Cryptosis)

Ingrowing toe nail is an extremely painful and distressing complaint which is caused essentially by the pressure of the shoe against the toe. The soft parts are forced against the nail and if it has been carelessly trimmed and has a sharp edge considerable pain results. Nature normally protects the skin from the sharp nail edge by laying down in the nail fold skin of a more horny texture than that in the immediate vicinity. The pain is caused by a splinter of nail growing forward along the lateral groove into the soft tissues. This is the lateral edge of the nail which owing to its hidden position has not been adequately cut. It grows forward and penetrates the subcutaneous tissues often carrying infection with it.

TREATMENT

Prophylaxis The nail should be cut at right angles to its long axis and not convexly which destroys to some extent the protective infolding of its edge.

The actual treatment of the established condition depends upon the severity of the case and the control one expects to have over the patient. In hospital patients for example radical measures are the most satisfactory but where time is not important as in private practice operation is seldom necessary.

Conservative Treatment This consists in removing all possible sources of pressure such as that of narrow shoes or narrow stockings.

and in removing the irritation caused by the pressure of the nail edge. Many a slightly ingrowing nail is best left alone the only precaution necessary being to warn the patient that he should cut the nail to its extreme edge (see Fig 370) thus avoiding the development of splinters.

Operative Treatment

The radical treatment consists of the removal of the sharp edge of the nail and its underlying matrix. A V wedge including about a third of the breadth of the nail along with the nail fold is excised from the lateral surface of the toe. The edges cannot be completely brought together but they are approximated as far as possible with silk worm gut sutures as small a surface as possible being left to granulate.



Fig 30—Ingrowing toe nail. The operation removes the whole of the abnormal and painful area.

This operation is not always successful as often spicules of nail grow at the edges irregularly and give pain. In amputation of the tip of the toe with removal of the nail bed and terminal phalanx gives a good result and does not affect function. Excision of the whole nail bed together with a thin slice from the dorsal aspect of the phalanx to which the nail bed is so intimately connected followed immediately by a whole thickness skin graft is done with success.

In the presence of chronic sepsis suture must not be carried out. A small vaseline dressing is applied to the raw area which is allowed to heal by granulation tissue.

Operation should not be carried out in the presence of acute inflammation.

ONYCHO GRYPHOSIS

This condition sometimes called Ram's Horn Nail or Ostler's Toe (because of frequent injury from the tread of a horse's foot) affects usually the great toe nail and is an irregular hypertrophy of the nail whereby it grows to a considerable size is irregular hard cross ridged and is curved with its convexity upwards instead of the normal flatness. The proximal aspect grows more rapidly than the distal and so the nail curves forwards and downwards and may ultimately erode into the pulp of the toe become infected and it is said may develop into a malignant epithelial growth. Injury and infection are alleged to be the cause.

TREATMENT

In the aged and bedridden in whom the condition is common due it is said to the constant trauma of the bedclothes palliative treatment is obviously proper. This is best carried out by a chiropodist who

keeps the growth in check by frequent paring and softening, if necessary by Liquor Potassi or Salicylic Acid. Complete excision of the nail bed is the best treatment since removal of the nail itself is followed by further deformity in the new growth. This may be done by an amputation of the terminal phalanx or by accurate dissection of the nail bed followed by a skin graft.

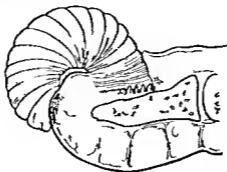


FIG 31—Onycho gryphosis. The nail eventually may grow into the pulp and produce an ulcer.

HYPERIDROSIS

Excessive perspiration of the feet may prove a most disagreeable and troublesome affection. The stockings and the shoe leather become damp and bacterial growth induces a pungent and penetrating odour.

The condition is really a functional disease of the sweat glands of the feet and is probably nervous in origin. It is commonest in young males and is frequently associated with the weak type of foot.

TREATMENT

In the mild cases nothing further is required than a frequent change of stockings which should be of wool and before being worn they should be well powdered with equal parts of boric and salicylic acids.

When the soles of the feet are particularly affected cork insoles should be worn in the shoes, a fresh pair being inserted whenever the stockings are changed and the feet should be bathed frequently in hot and cold water alternately dried, rubbed with alcohol and powdered.

When the smell is disagreeable a solution of chromic acid 40 grs to the oz. may be employed about once a week as a foot wash.

At the same time the general condition of the patient should receive attention as he is often run down, anæmic and nervous.

THE SESAMOID BONES OF THE GREAT TOE

The cartilaginous precursors of the sesamoid bones appear in early fetal life but do not ossify until between the ages of 8 and 11. Ossification may occur from a single centre or from several centres which

are extremely variable in position. In 10 per cent. of individuals these centres do not unite, constituting the condition of multipartite sesamoid.

Fracture of the Sesamoid Bones

The sesamoid bones of the great toe, particularly the medial, are occasionally fractured. The violence may be either direct or indirect, but usually results from sudden falls upon the feet, or the dropping of heavy weights on the toe.

The symptoms are those of a sudden sharp pain, at the time of the injury, or at a later date, pain following the appearance of secondary changes. The pain is situated over the affected sesamoid, and is aggravated by movement of the metatarso-phalangeal joint of the great toe. It tends to diminish with rest, but returns on exercise, so that the patient is often forced to walk on the lateral side of the foot. Tenderness can be elicited by direct pressure on the plantar surface of the damaged sesamoid.

The diagnosis of a fractured sesamoid should be made with reservation owing to the frequency of the multipartite condition. In the multipartite condition, the gap between the separate portions is even, the long margins smooth, rounded, and well calcified, whereas fractured edges are indented and irregular and porotic. Congenital subdivisions are also said to be usually transverse, and rarely oblique or longitudinal, although both of these have been described. The degree of separation is further said to be wider in fractures than in congenital separations.

Inge and Ferguson believe that a diagnosis should not be made unless a previous X-ray shows the affected bone to be complete, or unless subsequent X-rays or pathological section demonstrates callus.

These authors have operated on 41 cases of pain in the sesamoid bone following trauma, and were unable to demonstrate any specific pathology in the bones themselves. The pathological conditions present, to which they ascribe the pain, were inflammatory changes in the bursæ in relation to the sesamoid, and arthritis. In several cases, the outstanding error was a subluxation of the whole or part of the bone.

TREATMENT

The injured foot should be immobilized in a plaster-of-Paris case which includes the great toe until the fracture has healed—usually in from three to six weeks. If this treatment fails and the symptoms persist, the affected sesamoid bone, or bones, should be removed; but great care must be exercised in removing the bones from their tendons lest the tendons be severed. Both sesamoids need not and should not be removed unless there is a clear indication to do so since the excision of both increases the risk of dividing the tendon. The operation should be supplemented by adequate post-operative massage and early movement of the toe, and when the patient is allowed to go about, the incision should be suitably protected from friction-against the shoe.

CHAPTER XVII

SOME COMPLICATIONS OF TRAUMA

VOLKMANN'S ISCHÆMIC CONTRACTURE

In 1875 Volkmann described a contracture of the muscles of the wrist and fingers which followed tight bandaging of the arm in the treatment of fractures about the elbow. He believed that it was essentially due to ischæmia of the muscles and that as a result of deprivation of arterial blood the muscles suffered from want of oxygen, the condition he thought was thus akin to rigor mortis. He also showed that paralysis occurred simultaneously with the contracture, differing in this respect from the contracture which follows a primary nerve lesion.

INCIDENCE AND ETIOLOGY

The condition occurs most commonly in children in the first ten years of life and follows injuries particularly to the elbow and especially those associated with pressure either internal or external.

The condition in the past has generally been accepted as a complication of an improperly treated supracondylar fracture of the humerus but there is now evidence that it is the result of ischæmic infarction produced by a segmental arterial spasm of the main artery to an extremity with reflex spasm of the collateral circulation. A subtotal ischæmia is produced and the muscle bellies, demanding the greatest amount of blood and therefore the most vulnerable tissue to its loss, are first affected. Possibly gangrene of the finger tips would occur if the spasm continued in sufficiently severe degree but the usual result of ischæmic contracture implies that some improvement in the collateral circulation intervenes. This vasomotor activity is under control of the sympathetic nervous system.

Foix has recently reviewed many case histories and states that the findings of the various operators were very similar. The injury is usually a fracture or injury of the upper arm and in the cases where the injured site was explored a profound segmental arterial spasm was discovered. Usually at a point about 2 centimetres above its bifurcation the brachial artery was pulsating normally or even a little dilated but below that it suddenly became narrowed to a string-like size extending down into the radial and ulnar branches. The injury need not directly affect the vessel to produce the spasm. Although there may be a minor injury to the vessel wall that is not sufficient to occlude the vessel by the damage itself but causes the artery to occlude itself probably through the sympathetic nerves. A similar spasm is seen

following the lodgment of an embolus, and in fact may result from any disturbance of the peripheral circulation. The operation of arteriectomy in cases of embolic lodgment in a peripheral artery is based on this fact. It is evident that a good collateral circulation is capable of supplying all the needs of the peripheral circulation and that the chief danger in cases of main artery occlusion lies in the degree of constriction or dilatation of the collaterals that are under sympathetic vasomotor control.

An etiological factor of great importance is the treatment by acute flexion so frequently employed in fractures about the elbow joint. Intel ligently used, no method could be more satisfactory, but it is liable to cause vascular irritation and unless it is carefully supervised Volkmann's contracture may easily follow. The importance of correcting the displacement in supra condylar fractures efficiently and quickly is also obvious.

PATHOLOGY

The gross picture, which is one of central degeneration of the muscle bundle, is duplicated histologically by only one other condition, infarction. The most extensive degeneration occurs in the centre of the muscle sequestrum, and cellular activity and fibrosis take place only at the periphery, which is surrounded by a sheath of dense fibrous tissue. In the centre of the mass, the muscle fibres lose their nuclei and cross striations, and fuse into a homogeneous mass, with little more than a defining membrane separating them. As the periphery is approached, some signs of function are preserved, and there is an area of intense cellular activity, both fibroblastic and phagocytic. This picture is in contrast to muscle degeneration from all other causes, such as denervation and sepsis, in which the appearance is one of diffuse interfibrillar fibrosis.

The succeeding phases are those of replacement. Fibroblasts appear, and deposit fibrous tissue, at first in thin threads and later more densely. The whole process thus seems to be one of absorption and replacement by fibrosis of dead muscular tissue. A similar condition has recently been described affecting the anterior leg muscles caused by œdema in a patient taking much unaccustomed exercise.

SYMPTOMS

The symptoms usually begin within a few hours to twenty four hours of the injury. At this time definite signs of ischæmia appear, the hand becomes cold and swollen, with usually a pale cyanosis, and the fingers become functionless. Often there is intense pain, especially on attempted movement and numbness in the fingers, ultimately voluntary movement is totally abolished. The complete process is over in the first two days, so that the necessity for prompt initial treatment is very urgent. After this period the swelling gradually disappears and the muscles become hard, fibrosed, and resistant. As the fibrosis increases, deformity becomes obvious—especially flexion of the fingers. The fully developed picture is very characteristic: the wrist is flexed, the fingers ex-

tended at the metacarpo phalangeal joints, and flexed at the inter phalangeal joints, while the forearm is often pronated and the elbow flexed.

There are various degrees of the deformity.

1 Mild degrees are often first brought to the consultant several years after an injury to the elbow. The patient may be unable to extend the fingers completely but yet may possess a considerable range of movement when the wrist is flexed, indeed, it is usually possible to straighten the fingers completely with the wrist fully flexed.

2 The severe type, with the fully developed and characteristic attitude described on the previous page.

3 A severe type complicated by nerve involvement. Either the median or ulnar nerve may be coincidentally involved, but it must be remembered that, where the primary lesion is a supra condylar fracture these nerves may be injured, not by the Volkmann's contracture but by the projecting fragments of bone. In the absence of direct damage, however, either nerve may be imbedded in the actual ischaemic contracture. The median nerve is frequently compressed where it passes between the two heads of the pronator teres and the ulnar nerve may suffer from the contraction of the fibrous tissue which surrounds it, and in each case, the signs are those of an incomplete nerve lesion—usually partial.



FIG 372—Ischaemic Contracture of the Forearm Muscles.



FIG 373—Ischaemic Contracture. Extension of the fingers is possible only while the wrist is flexed.

anaesthesia, and paralysis of the small muscles of the hand. In addition the nutrition of the limb is impaired the hand is cold and blue, and trophic ulceration occurs.

PROGNOSIS

The prognosis will depend upon the stage at which treatment is instituted. The earlier it is undertaken, the better the prognosis is likely to be. The outlook is grave in the severe types, and in cases with accompanying nerve involvement, but in the slighter degrees of contracture, without nerve involvement, treatment usually gives a comparatively good result.

PROPHYLAXIS

The condition of the forearm and hand must be carefully watched in the early stages of treatment of all injuries of the elbow joint, and in this connection supra condylar fracture of the humerus is particularly dangerous. The position of the elbow joint after reduction of these fractures will depend upon the extent of any swelling present, and it is only in a very few cases that it has to be acutely flexed, in every case, however, the forearm and hand should be carefully supervised for some time.

It is inadvisable to treat fractures about the elbow with plaster of Paris splints or bandages particularly if they are applied in a circular fashion. In all cases of elbow injury a look out should be kept for pain, stiffness, swelling, cyanosis or lividity of the fingers, or obliteration of the radial pulse. If the patient is unable to move his fingers voluntarily, the splint should be removed and reapplied more loosely, or the amount of flexion slightly diminished.

TREATMENT

The treatment may be divided conveniently into various stages.

1 The Acute Stage The goal of treatment is to restore adequate circulation before irreparable damage is done and thus to avert contracture deformities. In treatment time is a major factor. The condition is a progressive one in which more and more damage is done. All measures favouring circulation generally are of the greatest value. These include elevation of the part, removal of any splint or circular bandage and the application of mild external warmth. The other limb, or other limbs, may be warmed as is done in immersion foot.

The next logical step is the interruption of the sympathetic reflex, arc by ganglion injection or arteriectomy. The former is tried first, and if successful its results are at once apparent and an open operation is avoided. The appearance of a Horner syndrome is evidence of a successful cervical sympathetic block. The local arterial spasm may, however, be the result of a local reflex that does not include the paravertebral ganglions and so the injection cannot be expected to be universally successful and if circulatory improvement is not immediately apparent or maintained the artery should be exposed. This at once affords an opportunity of relieving any abnormal venous pressure, of determining any local trauma to the artery and of completely interrupting the sympathetic arc by arteriectomy. Arteriectomy, in addition to the complete interruption of the reflex, has the advantage of the removal of a segment of the vessel which possibly contains a small break or tear not grossly visible, yet sufficient to maintain continued abnormal sensory stimuli. Its removal effectively produces vaso dilatation of the collateral.

If the X ray examination which should have been completed by this time, does not show perfect reduction, the question of improving

the alignment must be considered. It will be better in most cases to complete the reduction by open operation, since additional manipulation will further traumatize the tissues, and so increase the pain, and probably the deformity also.

2. Treatment of the Fully Developed Stage

(a) Mechanical Treatment. Manipulative Treatment. The wrist is passively flexed by an assistant and each finger fully extended and the extension is maintained by a palmar gutter splint secured with adhesive strapping. Thereafter, an attempt is made to extend the wrist by means of a cock up splint, applied at first with the wrist in the fully flexed position, and then slowly straightened to stretch the contracted muscles. The splint should be kept on for some time after full hyper extension of the wrist and fingers is obtained, until the tendency towards fibrotic contracture has ceased. It is advisable to remove the splint each day for massage, radiant heat, and stretching exercises. With the help of a good masseuse, the function of the hand should improve greatly, the circulation increase, and the fingers acquire greater voluntary power.

(b) Operative Treatment. A great variety of operations have been recommended for this condition, from tenoplasty, bone section, and excision of the elbow joint, to the muscle sliding operation described by Max Page. In every case, operation should be preceded by a course of thorough stretching as described above.

Littlewood recommended lengthening of all the shortened tendons,

but this is a serious operation in a young child, and requires great care and neatness if even a moderate result is to be secured. It should be attempted only if the contraction is limited to one or two of the forearm muscles.

Shortening of the bones of the forearm by resection of $\frac{3}{4}$ to 1 inch from each is also a severe operation, and, according to Sir Robert Jones, it is liable to be followed by non-union due to the trophic changes in the arm. The operation is recommended by Garré, but the results are not encouraging.

The operation which meets with most general approval now-a-days is that of Max Page.

✓ A straight incision is made from just above the medial epicondyle downwards for about 1 inches on

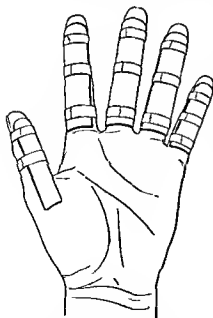


FIG. 374.—Ischaemic Contracture
Method of splinting the fingers

the medial aspect of the forearm and the flexor muscles, arising from the medial epicondyle of the humerus and the upper ends of the radius and ulna are raised from their origins by a periosteal elevator. The hand and fingers are then hyperextended and in this way the muscle origin is dragged downwards. The muscles obtain in time a new origin lower down the forearm. In performing the operation great care must be taken to avoid the ulnar nerve if the nerve is involved it should be freed from the surrounding fibrous tissue and at the same time the median nerve may be similarly dissected out and freed. The after treatment consists of careful splinting of the hand and fingers and reasoned physiotherapeutic treatment.

Treatment of the Nerve Complications When there is clinical evidence of nerve involvement which does not show any sign of clearing up after a reasonable period of two or three months' physiotherapeutic treatment the nerves should be explored at the sites where they are most likely to be compressed. The median nerve should be freed from the callus of the fracture and also released from compression as it passes under the superficial head of the pronator teres. The ulnar nerve is freed throughout the length of the flexor muscle bellies. General physiotherapeutic treatment should afterwards be carefully carried out the muscles at the same time being protected from over stretching by adequate splints.

MYOSITIS OSSIFICANS CIRCUMSCRIPTA

Intramuscular ossification may occur under many conditions. Gruta suggests the following classification—

1 *Myositis ossificans traumatica*—

(a) Following a severe single injury or the application of blunt force

(b) Following dislocation

(c) Following clean incised wounds

2 *Myositis ossificans chronica*—

(a) Occurring after repeated slight injuries

(b) From occupational strain of certain muscle groups

3 *Myositis ossificans* of infectious origin

4 *Myositis ossificans para arthritica*

5 *Myositis ossificans neurotica*

The traumatic type following a single injury is by far the most frequent accounting for about 75 per cent of his cases and it occurs most commonly in the anterior and lateral aspects of the thigh and in the upper arm. It is liable to follow a backward dislocation of the elbow.

It is not uncommon for bone to appear in the scar of a clean incised wound of the abdominal wall.

The chronic type of myositis occurring after repeated slight injuries is most often seen in the 'rider's bone' of the adductor muscles where

it arises because of the steady irritation of horse back exercise. Joiners and shoemakers not infrequently show some bone formation in certain muscles either from overstraining or from repeated slight injury.

An infectious type is said to follow spinal abscesses or compound fractures of the forearm.

Gruta described the para arthritic form for the first time and he stated that it arises in muscles and tendons in relation to joints the site of chronic inflammatory processes such as arthritis deformans or tuberculosis.

Ossification has been reported in muscles and tendons in association with tubercles, syringomyelia and myelitis.

INCIDENCE

Myositis occurs usually in early adult life between 17 and 25 years it may arise at a much later age however and cases of the disease in patients of 70 years of age have been reported. The muscles most commonly affected are the quadriceps and the adductors in the lower limb and the flexors of the elbow in the upper limb.

ETIOLOGY

Many theories have been advanced to explain the occurrence of myositis ossificans and they fall naturally into two groups.

1 That the new bone arises from the periosteum of the adjacent bone.

2 That the new bone arises by metaplasia of the local fibrous tissue.

If the periosteum is injured as for example by a severe blow, the osteoblastic layer may proliferate and osteoblasts escape into attached muscle in which they deposit bone. The periosteum at the site of muscular insertions may be torn by traction on the muscle and the osteoblasts be liberated in this way.

The metaplastic theory is based on the clinical observations of Orth who states that in most cases no connection even of fibrous tissue can be found between the skeletal bone and the adjacent mass in myositis ossificans. The radiological examination also shows that the ossifying process is unlike the orderly formation of new bone from the periosteum since it shows scattered centres of ossification in the midst of clear areas or spaces. The existence of metaplasia is well known to pathologists and can be seen in almost every part of the human body so that there seems no reason to doubt the ability of the fibrous tissue to become converted into bone. Some authors have reported an increase in the amount of calcium salts in the blood serum during the occurrence of metaplasia while Zanoli believes that the main factors in metaplasia are intoxication and infection the toxins acting as irritants to tissues in a state of lowered resistance. Experiments, however, have failed to substantiate either of these two theories and most investigators are of the opinion that there must be in addition a congenital factor.

Virchow and others believe that there is a constitutional tendency—a Diathesis Ossificans—for fibrous tissue to react to injury by metaplasia into bone

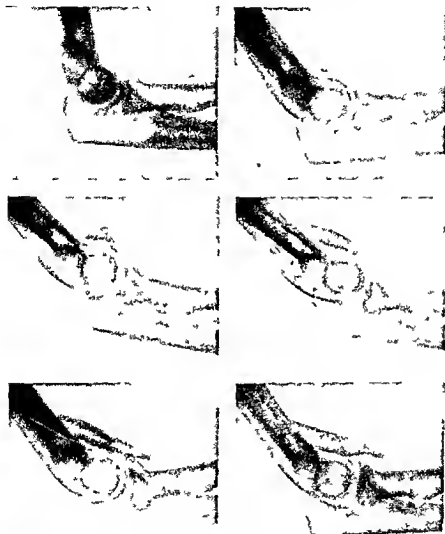


FIG. 375.—From a case of Intra-muscular Osteoma following on dislocation of the elbow

The first picture was taken three weeks after reduction the others at intervals of two months seven weeks seven weeks nine weeks, and five months respectively

PATHOLOGY

The new bone differs both in form and in size from normal bone, and there may be large irregular masses of it occupying almost the whole of the muscle. The mass may be entirely separate from the shaft, or joined to it by a fibrous band, or even by a bony pedicle. Cysts are liable to form in the swelling, and microscopically an irregular

mixture of bone cartilage muscle and connective tissue can be seen. Occasionally ossification occurs in the tendons both above and below the joint in which case an extra articular but complete ankylosis of the joint results.

The Course of the Disease The course of the traumatic form is typical and may be divided into three stages

1 In the first stage the traumatic symptoms predominate lasting for a few days during which time there is usually some swelling and limitation of movement which improves but does not entirely disappear as the acute symptoms subside.

2 At the end of the second week, or even later pain reappears movement becomes further limited and the original swelling slowly increases. At the end of four weeks the X-ray film may show an irregular and distinct shadow parallel to the bone but separated by a light zone.

3 In the third stage the growth of the swelling may stop or the lump may slowly increase by continued deposition. The pain disappears and the X-ray film shows a sharply limited mass which is smaller denser and more homogeneous than before.

The period of active growth varies from ten weeks to six months and inflammatory symptoms are practically never associated with the swelling.

DIAGNOSIS

The diagnosis is not usually difficult except in the early stage when many confusing conditions such as hematoma callus muscle tumours osteomyelitis syphilitic conditions periostitis and neoplasms have to be excluded. The most important and sometimes the most difficult lesion to differentiate is sarcoma both have many points in common—they develop in young persons usually after trauma they grow quickly and are hard in consistency, and the time which elapses after the original injury is usually the same. The features that assist the diagnosis are



110 3 6—Myositis Ossificans in the Quadriceps Muscle of the Thigh.
The entire mass disappeared after rest.

1 Sarcoma is usually situated near the epiphysis, whereas myositis is over the shaft. 2 Sarcoma grows more lavishly, and eventually invades the soft parts. 3 Late spontaneous and severe pain which tends always to increase, indicates a neoplasm. A tendency for the swelling to diminish in size, and its uniformly hard consistence together with pain which occurs early and gradually loses its intensity, are the peculiar features of myositis ossificans. On X ray examination, the cortex and the periosteum are normal in myositis, and the newly formed mass lies parallel to the surface and separated from it by a distinct area, in sarcoma on the other hand, there are early medullary changes, and early destruction of the cortex, while the bony mass contains trabeculae which are obliquely or transversely disposed in relation to the shaft, with which they are visibly connected.

Yet there are cases which are extremely difficult to differentiate. Often the patient is unable to remember any trauma. In the early stages a sarcoma shows little change in the bone and somewhat later—about the second month—the myositis shows some local decalcification of the underlying cortex which may suggest a sarcomatous origin, but in the sarcoma the erosion is associated with absorption of the spicular periosteal accretions immediately over it. The bone in myositis gradually increases in density and the symptoms almost as gradually subside. A biopsy is not usually indicated because expert pathologists may mistake the two and because in the acute stage of a myositis surgical interference increases the ossification.

TREATMENT

Even without interference myositis displays a marked tendency to retrogress, and eventually to disappear completely, and early operation is frequently followed by recurrence. the consensus of opinion, therefore, is that conservative measures should be adopted, particularly in the early stages of the process. Any form of treatment which stimulates or irritates the affected part may favour or increase the intramuscular ossification. hence massage, forced passive movements, and even active movement should be prohibited at first. Jones and Lovett point out in this connection that the modern practice in elbow injuries of enforcing rest, with the forearm supported by a sling and the elbow acutely flexed is rarely followed by this complication. The part should therefore be rested, and all physiotherapeutic treatment discontinued. X rays should be taken at regular intervals, in order to observe the growth or otherwise of the mass.

Excision of the mass should not be contemplated until it has become stationary and should be undertaken then only if the lump is unusually large, or is causing great limitation of movement.

FRACTURES

A detailed review of the treatment of fractures is outwith the scope of this book, but some of the disabilities which result from them will be discussed briefly. A certain number of fractures result in deformity, and in impairment of function, the objects of treatment, therefore, are to abolish the deformity and to restore complete function. Thus in the primary treatment of fractures the first essential is to secure good alignment of the fragments, so that the joint components may retain their correct relationship. In this connection it may be said that while correct apposition of the two ends is the ideal to be striven for, slight overlapping with the fragments parallel is compatible with good function and is better than angling, angling of the fragments results in deflection of body weight, as a result of which the joints above and below the fracture are subjected to abnormal strains and stresses. The second essential is to obtain good union, and the third is to preserve the joint function which means the preservation of full joint mobility.

The late complications of fracture for which the services of the orthopaedic surgeon may be sought are

Delayed Union

Non Union

Val Union or Union in faulty position

Each of these presents an individual problem

Delayed Union

A fracture is said to be healed or united when there is more or less complete continuity between the fragments. The process of healing or union is accomplished in four stages.

1 A stage of preliminary fibrous union or union by granulation tissue

2 The formation of soft callus

3 The formation of hard callus or bone

4 Adaptive reconstruction of the callus to restore the original architecture of the bone

It is not always easy to decide when union is delayed since the time of healing of fractures varies considerably, but the sites where delay most commonly occurs are the lower third of the tibia, the middle third of the humerus and the middle third of the femur. If the tibia is not completely united in eight weeks, the humerus in six weeks, and the femur in ten weeks, i.e. where there is still considerable mobility between the two ends after these periods, delayed union is present, though at this stage it does not require any active treatment.

As the delay may be due to inefficient reduction, it becomes very necessary to obtain good alignment to maintain it, and at the same time to see that the circulation of the limb is maintained. Union is frequently delayed in compound fractures. Loss of bone removal of bone by opera-

tion separation of the fragments by too strong traction incomplete immobilization—especially when rotation of the fragments is permitted—are all obvious causes of non union

Amongst the constitutional causes of delay are advanced age and the presence of some acute or chronic disease and it has been suggested also that the calcium and phosphorus content of the blood may be diminished in some cases

TREATMENT OF DELAYED UNION

In general it may be said that measures directed towards the improvement of the patient's condition will facilitate union between the bone ends in fracture

The commonest local method of dealing with delayed union and one frequently attended with a marked degree of success is the Ham and Dain method originally described by Thomas many years ago which consists in stimulating the bone ends and congesting the area of the fracture. A passive hyperæmia in the vicinity of the fracture is obtained by the application of Martin's bandages 6 inches above and 6 inches below the level of the lesion. These are applied only tightly enough to produce passive congestion, and they are kept on at first for twenty minutes each day thereafter the time is gradually increased until they are worn for several hours in the twenty four. At the same time percussion is made in the long axis of the affected limb by means of a hammer—the heel suitably protected is firmly tapped in the case of leg fractures and the olecranon with the elbow at a right angle in the case of fractures of the arm. Under such treatment fractures which have been ununited for some months frequently heal.

Thomas's method acts presumably in two ways the local congestion may increase the local nutrition in the region of the fracture while the pounding may result in the formation of fresh granulation tissue.

Extract of parathyroid gland has been administered in the hope that it would produce bone growth and union of a slowly healing fracture but there is no proof that it has any constant effect on the production of bone. Experiments on dogs show that it has no influence on the regeneration of bone in adults although it seems that in young dogs it tends to delay deposition of calcium in regenerating bone. Lime salts have also been exhibited with as little success and phosphorus irradiated substances and ultra violet light therapy are similarly valueless but diathermy applied to the affected area seems to hold out some prospect of success.

The controlled use of the limb may have a beneficial effect in hastening union provided that it is carefully immobilized. The benefit may result in one or two ways—the pressure on the fractured ends may stimulate osteogenesis and the dependent position thus assumed may increase the local congestion in the fractured area.

Non-Union

In un united fractures the two fragments remain separate, and the bone ends are eburnated and sclerosed, a gap usually exists between the fragments, and there may or may not be an actual pseud arthrosis. The condition is permanent, and has to be distinguished from delayed union, in which the organization of the callus into solid bone is merely abnormally retarded. It is impossible to fix a time limit within which union should have occurred, but if mobility is still present at the end of six months the fracture may be considered un united. Cases have occasionally been reported however in which solid union has occurred at an even later period.

ETIOLOGY OF NON UNION

The process of healing may be arrested at any stage in the repair of the fracture and may be the result of local or constitutional errors or both.

Local Causes

- 1 The primary granulation tissue may fail to bridge the gap,
 - (a) because of the interposition of soft parts,
 - (b) because of mal alignment of the fragments
 - (c) because of the actual loss of bony tissue
- 2 The granulation tissue may become converted into fibrous or scar tissue before lime salts have become deposited, and the contraction of the fibrous tissue strangles the osteoblasts and deprives them of much of their nourishment.
- 3 Injudicious manipulations and imperfect immobilization may interfere with the formation of the granulation tissue, destroy the fine capillary buds and so lead to faulty local nutrition.
- 4 The blood supply to the fracture and its vicinity may be jeopardized by swelling or laceration of the soft parts and the addition of any of the other factors may then be sufficient to defeat the efforts at union.

Phemister has described an aseptic necrosis in fractures of the shaft and believes it to be a common cause of delayed union and non union. This condition is really due to a deficiency of blood in one or both fragments and is a sequel to the trauma that produced the fracture, it has also been called traumatic arterial ischaemia by Girdlestone. Bone cells require for their work an adequate supply of blood and any diminution of the blood supply tends to subdue their activities and, according to the degree of ischaemia the cells pass from quiescence to suspended animation or even death. The condition may be diagnosed from the X ray examination after some weeks when it is noticed that one or other fragment does not share in the general decalcification normal at this period. Girdlestone recommends continuous accurate immobilization and at the same time active function of the limb.

- 5 Infection has in most cases a destructive effect on the developing

callus and even on the fully formed bone, which is seen especially in the non union which sometimes follows the plating of fractures, where a low grade infection is present

Constitutional Causes

Among the more important general causes which predispose to non union may be mentioned—

Endocrin deficiencies,

Acute or chronic illnesses

Deficiency in the calcium and phosphorus content of the blood

When the un united fracture is exposed at operation, the cortex is found to be rough and usually devoid of periosteum for some distance on either side of the fracture. The bone ends may be either porous and atrophic, or sclerosed, and the callus over the proximal fragment is usually greater than that on the distal one. There may be a fibrous union between the fragments or a definite joint cavity may exist with bursal sac synovial fluid, and joint capsule the so called pseudarthrosis or 'false joint'. In some cases the fragments are atrophic, and terminate in cone shaped ends which are covered with dense fibro cartilage.

When delayed union follows a severe trauma the periosteum is usually thin and difficult to raise from the bone without tearing and shredding. Mott believes that the periosteum, alone of all the bone constituents plays a definite role in bone regeneration, despite the fact that Leriche has emphatically stated that the periosteum has no true osteogenic function. Cowan believes that in fractures the injured periosteum produces granulation tissue, which quickly becomes transformed into dense avascular fibrous tissue that granulation tissue is also thrown out by the bone itself chiefly from its marrow tissue and that this is pro-callus in which the fibres are delicate and scanty, and the blood vessels numerous, and in which deposition of calcium salts occurs early. The final results of the reparatory process depend, according to him, upon the preponderance of one or other of these granulation tissues. If the medullary procallus is in excess bone union is assured, the denser avascular periosteal tissue however seems to choke the more delicate vascular pro callus and prevents its fusion with the pro callus of the other fragments. Cowan attempts to obtain union by shutting out the periosteum from the area of fracture, and so preventing its granulation tissue invading the gap between the bone-ends.

CLINICAL FEATURES

The signs of non union vary from slight movement between the fragments associated with pain, to pseudarthrosis and complete impairment of function. Where the union is almost complete the mobility may be very slight but pain is usually experienced on active use, and is followed by swelling. Great care is necessary to distinguish non union from delayed union, the distinction is best made by repeated clinical examinations and successive radiographs.

TREATMENT

1 Mechanical Treatment

Treatment of non union by mechanical means is merely palliative and is applicable only when the general condition of the patient or local condition of the limb makes operation inadvisable

When the humerus has failed to unite a sheath of leather may be used which should extend as high as possible and reach down to the elbow joint and should be attached to a sheath on the forearm by means of a joint at the elbow. The addition of a forearm piece makes the arm more useful and more stable

In an united fracture of the femur some form of walking caliper splint such as Thomas's in which the weight is taken on the tuber ischii is the best form of apparatus. Again a sheath of leather should be incorporated in the splint to encircle the thigh

When the tibia is un united a short caliper from the heel of the boot to below the knee along with a leather cage, is sometimes all that is required in many cases however a walking caliper such as is used for the hip is necessary

2 The Operative Treatment

The effective treatment of non union is essentially surgical but in old compound fractures there is ever present a fear that operative interference will light up a previous pyogenic infection as organisms may lie dormant either in the bone ends or in the scar tissue between them. Operation should never be considered, therefore until all evidences of an inflammatory process have subsided—until the wound has been healed for from four to six months. Unfortunately there is no time limit beyond which the lighting up of a latent infection does not occur and wherever there is an element of doubt about such latent sepsis it is the practice of the author to apply hot fomentations or radiant heat to the limb for a period of twenty minutes and then massage the affected part firmly and deeply manipulating the fragments at the same time. If this is carried out regularly for a fortnight there is every likelihood that any latent infection will reveal itself and after a fortnight's treatment without any sign of inflammation operation can be undertaken safely. In cases of non union following a compound fracture it is a wise procedure to perform the operation in two stages

During the first stage the wound scar is excised down to the bone in order to eradicate tissue which is possibly infective and to ensure that the bone ends will be ensheathed by healthy vascular tissue. At the same time also the bone ends may be prepared for the second operation by excising the fibrous tissue which covers them. If satisfactory closure of the wound cannot be obtained after excision of the scar an amyle pedicle graft may be taken from the opposite leg to make good the deficiency

The major procedure—the fixation of the fragments—may be undertaken by any of the methods enumerated below but it should not be

contemplated until at least one month has elapsed since the preliminary operation

The methods of uniting the fragments vary in character and complexity according to the circumstances of the case. The following procedures are available

(a) **Drilling the Fragments** There is a type of non union in which the fragments are apparently in good apposition and in which there is no interposition of soft tissue but where the radiograph shows that there is marked sclerosis and avascularity of the bone ends. In such a case union may be obtained by the very simple procedure of Beck which tends to promote natural callus formation. One or two small incisions are made at varying points round each bone end through each of these openings a fine drill, $\frac{1}{8}$ inch in diameter is introduced and twenty or thirty holes drilled in the fragments. The ends of the bones in consequence become vascularized, and a fresh osteoblastic reaction occurs. After the operation the fracture is immobilized on a splint and treated as a case of delayed union. This operation is a simple one and unattended with risk while if unsuccessful it has at least done no harm and has not prevented the performance of one of the major operations later.

(b) **The Step up Operation of Sen** This is regarded as the operation of choice in an united fracture of the humerus, where shortening of the limb is of less consequence than in the leg. After the scar tissue has been removed and normal vascular soft tissue exposed in the vicinity of the fracture each fragment is brought out into the wound and divided longitudinally by a saw for about $\frac{1}{2}$ inch. The saw cut is brought out on the medial side of one fragment and on the lateral side of the other so that about $\frac{1}{2}$ inch of bone consisting of half the diameter is removed from the opposite sides of each fragment. The fragments are then fitted together clamped in position and united by two transfixing pegs. After the operation the arm is put up in a Jones's humerus traction splint with an angled forearm piece. Union may be slow but is usually complete in from six to eight weeks.

This is the most successful method of treating an ununited fracture but it has the great disadvantage that it cannot be applied to fractures of the leg since it is followed by a considerable degree of shortening.

(c) **Bone grafting Operation** This is the ideal method of dealing with ununited fractures of the leg. In the first place the graft acts as an internal prop which helps to keep the fragments in alignment it serves further as a conductive bridge along which new developing bone may cross from one fragment to the other and it provides a source of new bone reparative tissue. An autogenous graft is best but dead animal bone prepared and sterilized beforehand, may be used in the form of plates or pegs, provided there is no gap between the fragments.

Os Purum (Orell) consists of animal bone prepared by mechanical cleaning, soaking in salt solution to dissolve out the proteins, then

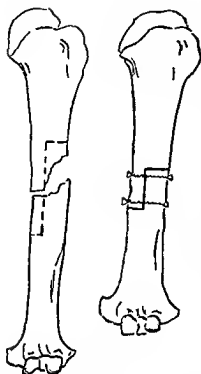


FIG 377—Non union of Diaphyseal Fractures

The stepping operation frequently carried out in the humerus

implanted between the ends of an ununited fracture, it continues to live as a bone graft and derives nutrition from the tissue fluids in the neighbourhood, indeed the tissue composing the graft is capable of long survival if a satisfactory blood supply and good nutrition are ensured. Albee states that if it is so placed that the various elements of the graft—the periosteum, cortex, endosteum, and marrow—make direct and intimate contact with similar elements in the host, the soft tissues of the bone first unite across the narrow gap, and vascular continuity between the bone of

in warm potassium hydroxide to remove the connective tissue, and lastly in acetone to remove the fat. Such grafts of various shape are used in any situation where they can be placed in a continuous vascular bony bed and serve as a skeletal framework into which new bone cells grow. *Os Norum* can be used to bridge gaps in ununited fractures and is produced by placing a strip of os purum under the periosteum of the patient's tibia and leaving it there for three months. At the end of that time it can be implanted on the site required together with the mass of fresh bone cells adhering to it. Orell is satisfied that a firmer and more rapid union is obtained than by massive autogenous grafts.

The Fate of the Autogenous Graft. When an autogenous graft is

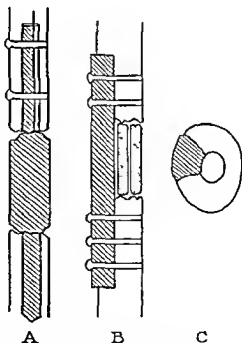


FIG 378—Non union of Diaphyseal Fractures

Bone-grafting operation carried out where it is necessary to preserve length in a bone (after Hey Groves)

the host and that of the graft is re established through the periosteum and the marrow and a granulation tissue bridge is laid down between the bony surfaces. Later osteoblasts appear in the granulation tissue and determine the deposition of lime salts. Thus under ideal conditions the greatest possible number of the capillaries of the host and of the graft are brought into the closest mutual approximation and the graft remains intact. If such conditions are not provided smaller or larger areas of the graft fail to obtain nourishment and ultimately die and are replaced. If all the elements of the graft cannot be brought into contact with similar elements of the host at least the marrow should. Johnstone insists that 75 per cent of the circulation is re established by the marrow and 25 per cent by the

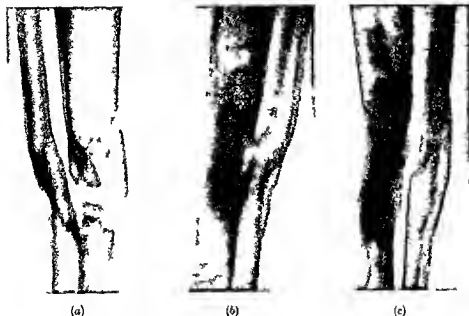


FIG. 379.—Non union of the Tibia following a Gun shot Wound. (a) The gap fracture. (b) A sliding graft has been used to bridge the gap and union has taken place. (c) Three years after the operation.

periosteum indicating the relative share which these tissues have in osteogenesis.

It is of the utmost importance that the approximation of the surfaces of the graft and of the host should be as accurate and as wide as possible. If the surfaces are poorly approximated more granulation tissue is required to bridge the gap and healing is accordingly slow, but if the tissues are brought into close contact the layer of granulation tissue is of microscopical thickness and healing by first intention results. It is equally important to ensure firm fixation of the graft to the host since slight movements may in such rigid tissue as bone tear the delicate granulation tissues or blood vessels or even fracture the soft

callus The graft should be a massive one—at least one third as long and three quarters as wide as the bone to which it is applied

The treatment of an ununited fracture unlike that of a recent one is not a mechanical problem When union fails, the problem passes from the realm of mechanics into those of physiology and biology The success of a bone grafting operation therefore, depends not so much upon securing by mechanical means a perfect apposition as upon producing suitable local circumstances to aid the formation of granulation tissue and later of callus

The intra medullary graft has to a large extent been given up, for since the marrow has been shown to be the most important source of blood the process of scooping it out in order to plug the medulla with a graft is manifestly prejudicial to union and should be avoided The only intramedullary graft likely to be successful is where a section of



FIG. 380.—Gap Fracture of a Metacarpal with Palmar Spur
Treated by bone graft from the tibia

the fibula is inserted into the femur, so allowing a continuous marrow cavity Indeed non union is not uncommon after the application of an intra medullary graft and is an unusually vexing problem because of the destruction of the marrow and the consequent aggravation of the ischaemia of the fragments

The osteo periosteal graft, first advocated by Olier has also been given up as the periosteum normally supplies only one third of the callus and blood which the endosteum and marrow contributes and nutrition of the graft and the formation of callus are correspondingly restricted In addition the osteo periosteal graft not only provides no mechanical continuity consisting merely of soft tissue to which plaques of new bone cling but also cannot exert an immobilizing effect Similar objections apply to the onlay graft except that with it anatomical continuity is preserved The use of beef bone is specially to be condemned, as its

osteolytic effect has been demonstrated both experimentally and clinically and if an heterogeneous onlay graft is ever used it should be secured by pegs or screws of autogenous bone

The Massive Inlay Graft This is the method of choice. The area of fracture is exposed by a generous skin incision made whenever possible through healthy tissue and access to the fracture should be obtained as far as possible without undue traction on the soft tissues. The bone ends are brought out at the wound and freshened with an osteotome and any anæmic scar tissue is carefully dissected away so that only tissue with a good blood supply will be in contact with the graft. The periosteum is then divided longitudinally on each side of the gap in order that a gutter may be made for the graft. The periosteal flaps are reflected on either side and the cortex exposed. Two parallel longitudinal saw cuts which go through the entire thickness of the cortex and extend for two or three inches from the line of fracture well into non sclerosed bone are now made in each fragment and the rectangular strips of bone so marked out are removed leaving a gutter. The cuts extend well into non sclerosed healthy bone. The length of graft required is now obtained by measuring the gutter and removing a similar length from the anterior surface of either tibia. The wound and gutter are packed with hot saline compresses while the graft is cut from the tibia. The graft is made of sufficient length to extend to the end of the gutter and of similar breadth, and has generous contact with the vascular marrow substance and normal bone cortex well on each side of the point of non union. In this way the marrow substance of the graft gets the best chance of being penetrated by the blood vessels of the host and so of acting as a vessel conducting agent. The graft is laid in the gutter and retained in accurate apposition and immobilized by four vitallium screws. The site of fracture is covered by the periosteal flaps which were reflected to expose the cortex obtaining in this way two layers of periosteum to cover the transplanted fragment and the overlying tissues and skin are closed without drainage. Where no soft tissue can conveniently be used to cover over the graft e.g. on the superficial aspect of the tibia a broad pedicled flap of fascia may be taken from over the adjacent calf muscles and folded back over the graft.

In some cases it is possible by means of twin saws, which can be varied in their proximity to each other to cut grafts so accurately that they can be wedged into the gutter and hammered home and so hold the bone fragments firmly while a plaster is applied. This accurate wedgement of the graft obviates the necessity of any other fixing material.

If the fracture is at the end of a long bone it may be possible to obtain a graft from the longer fragment by the sliding method. A rectangular graft is then cut from the shaft and slid along into a gutter prepared as above in the smaller fragment.

Matti describes a method which is technically easier than the massive graft operation. It consists in removing about one third of the thickness of both bone ends over the region of the fracture cutting out the dense connective tissue and packing into the open marrow cavity little pieces of bone into which the bone already removed has been cut up



FIG. 381.—Non union of the Radius

This case had several prior operations, including wiring and grafts. The graft, however, had been absorbed. A massive graft was inserted and the result of that is seen immediately and six months after the operation.

This method is most suitable for the tibia where the fibula has already united because the plaster case fixation will be easy.

A useful addition to cases where osteogenesis is doubtful is to apply thin slivers of bone alongside the fracture ensuring their contact by catgut around bone and slivers. Two or three such slivers are applied round the bone and appear to activate bone growth to a considerable extent.

Post Operative Treatment

The limb is immobilized in a plaster of Paris case which controls the joints above and below the fracture. Too much emphasis cannot be laid on the importance of applying and moulding the plaster carefully; it is even more necessary than after the reduction of the original fracture since movement of the graft and its gutter or the displacement of the graft from the gutter results in disturbance of the callus and destruction of the vascular bridges which form between the graft and the host and the operation is a failure. The plaster case may be applied by the sectional method so as to disturb the area as little as possible. The plaster should not be disturbed until at the end of twelve weeks it is bivalved and removed to enable an X ray examination to be made. No attempt should be made to test the consolidation clinically until the X ray is available. If union is still not complete immobilization is continued in the bivalved plaster casing but the case is removed daily to allow massage not only over the area of operation but uniformly over the limb to stimulate the circulation and callus formation. Free and full use should be forbidden until union is complete. Active physiotherapy has to be continued for a long period after the operation since joint stiffness and tendon adhesions are overcome only with difficulty. Radiant heat or diathermy are followed by manual massage which is of the greatest importance. In most cases in which the graft fractures or breaks away from its attachment to its host the fault lies in the careless supervision of the convalescent treatment.

UN UNITED FRACTURE OF THE NECK OF THE FEMUR

The subcapital fracture of the neck of the femur is without doubt one of the most disabling of all fractures since non union is a common sequel; the basal extra capsular or intertrochanteric fracture on the other hand heals with great readiness. It may not be out of place to consider briefly the question of treatment of the recent fracture since non union is so dependent on this factor.

The Whitman treatment—in plaster in a position of abduction, internal rotation and hyperextension—appeared at first to solve the problem of non union. For some time after its introduction the reports from various clinics particularly in America showed a high proportion of firm bony unions but since then this optimistic outlook has not been maintained and it is generally believed at the present time that over a long series of cases 30 to 40 per cent at most show complete union. Despite this the Whitman method is still much in favour though operative fixation is being done in an increasing number of fracture clinics. The author warmly favours the Smith Petersen nail where the condition of the patient permits.

The failure of union may be said to be due to three factors—an insufficient blood supply to the cervical fragment accompanied by senile changes in the bone, the presence of synovial fluid and in

complete coaptation or faulty alignment, of the fragments. Faulty apposition is undoubtedly the main cause. If a large series of cases showing non union is studied, in 75 per cent it will be apparent that at no time during treatment was end to-end apposition of the two fragments obtained. If, however, the displacement is accurately reduced, the deficient blood supply and the presence of the synovial fluid will not have any appreciably bad effect upon the union. When non union results the patient is usually unable to bear weight on the limb and must either wear for life a supporting splint, such as a caliper or

— undergo some form of operation. In the old and feeble conservative treatment should be advised. In younger cases, the operation may take one of several forms.

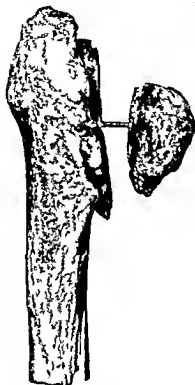


FIG 382—Old un united Fracture of the Femoral Neck.

Operative Treatment

1 **Sub - trochanteric Osteotomy** If the general condition of the patient is not good, Bohler believes that the best treatment of the pseudarthrosis consists in sub trochanteric osteotomy. Metal pins are inserted after the manner of Schanz to ensure that the abduction after the osteotomy takes place at the osteotomy site and not at the pseudarthrosis. The leg is retained in a plaster case which is left on for ten weeks. At the end of this time the patient is allowed to walk. Bohler believes that such a sub trochanteric osteotomy secures end to-end pressure between the two fractured ends of the neck and that union occurs provided that the operation is undertaken within a few weeks of the injury.

Any of the following major operations may be advised when the general condition and strength of the patient are such that a favourable outcome may be expected.

2 **The Peg Graft Operation of Albee** The hip joint is exposed by a Smith Petersen incision. The neck of the femur is inspected and lateral rotation of the foot and limb forces the distal fragment through the anterior part of the capsule, and both fracture surfaces are thoroughly freshened. The position of the limb is then corrected, and sufficient abduction and traction applied to bring the freshened ends into close apposition. A hole is drilled from the trochanter,

through the neck into the capital fragment. A graft is then taken from the tibia, inserted in the tunnel in the neck, and driven home with a bone mallet. With the handle held against the great trochanter close to the peg graft, the head of a wooden mallet is now struck with the palm of the hand or with a sandbag. In this way close approximation of the fragments is secured. The limb is then put up in a position of slight abduction, and a double plaster of Paris spica applied extending to the base of the toes on the affected side and to the knee on the sound side.

In view of the difficulty of obtaining close approximation of the fragments, and of retaining the apposition by a bone graft such as the above, some surgeons remove the head of the bone, and, after freshening the bone ends, drive the peg in from the capital side, thereafter replacing

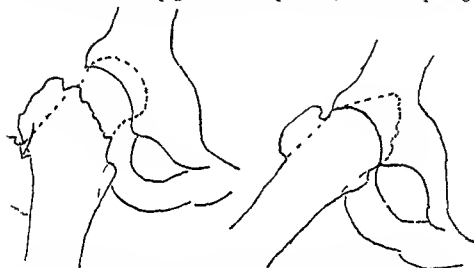


FIG. 383.—Operative Treatment of old ununited Fracture of the Neck of the Femur
Whitman's Operation

The head of the femur is removed and the end of the shaft placed directly in the acetabulum, the trochanter being transplanted downwards on the shaft.

the head. Better approximation and more permanent correction are attained by this method, but the operation is more difficult, more prolonged, accompanied by more shock, and attended with considerably more joint disturbance than the Albee method.

Smith Petersen uses a metal flanged nail instead of a bone graft, but in the author's experience this method of treatment, though very successful in recent cases, is of less value in old ones.

3 The Whitman Operation. The Whitman operation resembles the Brackett one, but is based on a different principle, in that the success of the operation does not here depend on the patient's power of bony union. Whitman removes the proximal fragment of the neck and the head of the femur. The portion of the neck attached to the distal fragment is retained, and its available length increased by shaving off the great trochanter along a line continuous with the upper surface of

the neck. The trochanter with its attached muscles is now reinserted lower down on the shaft to provide a new and more distal point of leverage. The neck is then implanted into the acetabulum to form a false joint.

The particular advantage of this operation is that apart from its independence of the osteogenetic power of the part it requires only a short period of immobilization. It is particularly useful in the older patient where the reparative processes are feeble and in whom a rapidly executed operation and a short period of fixation are all important. After six weeks in plaster the patient is fitted with a Thomas's walking caliper.

4 The McMurray Bifurcation Operation. This operation which has already been described on page 421 is a simpler method of improving function in an ununited femoral neck than any of those described. The upper end of the lower fragment is slid in towards the pelvis and attains a stable position. The limb is retained in plaster for four months at the end of which time the patient may walk on the leg unsupported by a caliper. Indeed the caliper is almost impossible to fit owing to the displacement of the shaft of the femur towards the *tuber ischi*.

Summary. The choice of method in the treatment of an ununited fracture of the neck of the femur must depend to a great extent upon the age and well being of the patient. The ideal to be striven for is the restoration of the normal relations in and about the joint. The best means of achieving this is by an autogenous peg graft inserted into the two fragments. This is only likely to be successful in fairly recent cases and where there is little sclerosis or necrosis of bone but in such cases this is the method of choice. When the surgeon has to be content with less severe and less exacting procedures the bifurcation osteotomy of McMurray is the best method. This gives a really wonderfully good functional result in that the leg is stable and shortening is avoided. There is however some limitation of hip movement.

MAL UNION OF FRACTURES OF THE CALCANEUS

Fractures of the calcaneus are amongst the most disabling of all injuries and so far as one is able to judge the victim never seems to recover completely the movements of inversion and eversion that occur at the talo calcanean (sub taloid) joint. He does however manage to rise on his toes remarkably well and may walk without a limp although there is a very noticeable loss of spring when running is attempted. Frequently traumatic flat foot results when the lateral and upward displacement of the posterior part of the calcaneus remains uncorrected. The heel is also often displaced laterally so that the line of transmission of the body weight falls over the medial side of the posterior pillar of the arch. The foot is thus forced over into an

abducted position and muscular strain is then inevitable. Spurs may form on the under surface of the bone from the extrusion of small fragments from the main body of the bone. As in joint injuries elsewhere improvement is slow and it may be three or four years before recovery reaches its maximum. Too gloomy a view therefore should not be taken of bad immediate functional results.

The ordinary fracture is a compression one and there are usually multiple cracks in the bone. It may even be severely comminuted.



FIG. 384.—Old Unreduced Fracture of the Calcaneus

The bone is broadened laterally the heel is swollen and tender and there is a prominence beneath both malleoli. In late fractures the patient complains of a considerable amount of pain from secondary arthritis of the talo calcanean joint.

TREATMENT

Treatment may be palliative or operative. Conservative treatment / which aims at correcting the faulty mechanics of the foot by means of arch supports, wedged heels, etc. is not usually attended with any great

degree of success. More can be done to improve the condition of these patients by producing a sub taloid arthrodesis. Indeed this operation is used by some surgeons as a primary method of treatment. In late cases there are certain procedures additional to an ordinary talocalcanean arthrodesis that make for a better result.

The Operation The technique of the procedure is as follows. After a tourniquet has been applied to the limb a curved incision is made along the medial surface of the calcaneus beginning immediately posterior to the medial malleolus and extending round the tip anteriorly and slightly upwards to the navicular bone. Care must be taken not to injure the important structures running under the malleolus into the foot. Dissection is carried on through the soft tissues and the sub taloid joint is exposed. The cartilage of the posterior articulation of the talus and calcaneus is removed with a thin osteotome. In order that a complete arthrodesis may result another incision is made on the lateral side extending from a point immediately posterior to the tip of the lateral malleolus then under the tip and slightly upwards to a point immediately dorsal to the calcaneo cuboid joint. As on the inner side the dissection is carried on to the bone carefully avoiding injury to the peroneal tendons. Cotton advises that a flap including the peroneal tendons the periosteum and acortical layer of bone be now stripped up and laid forward and upwards. All the excess bone and callus found here is now cleared away leaving a saucer like crater of bone. The talocalcanean joint is identified slightly above the tip of the malleolus and the remainder of the cartilaginous surface of the joint is removed. If there is outward deviation of the calcaneus the removal of bone is done so that when the apposing surfaces of the talus and calcaneus are fitted together the deviation will be corrected. Where badly comminuted it is better to do a modified Naughton Dunn arthrodesis. If the comminution affects only the subtaloid joint this should be arthrodesed in the same way that the author advises for arthrodesis of the ankle joint (p. 819). Pridie has recently reported good results in cases of considerable comminution by complete excision of the bone. The hematoma that produces plantar ischæmia is removed at the same time with great benefit.

MAL UNION OF A POTT'S FRACTURE

The term Pott's Fracture is employed to describe most of the fracture dislocations of the ankle. These injuries are particularly liable to lead later to disturbances of the joint mechanics.

Fractures about the ankle are classified by Ashhurst into lateral rotation fractures abduction fractures adduction fractures and hyper extension fractures, the usual lesion affects one or other malleolus or both. In addition to the malleolar fractures there is in 20 per cent of cases a fracture of the posterior marginal part of the tibia to which

since it acts as a buttress against the backward dislocation of the foot Trethowen has given the name of the posterior malleolus

Whatever the type of fracture the treatment is essentially the same it should be reduced by manipulation under an anæsthetic and the correction maintained by a plaster of Paris case. In cases where the posterior malleolus has also been fractured it may be necessary to undertake an open operation in order to reduce and fix the posterior malleolus

Unreduced fractures at the ankle are commonly accompanied by severe disability of the joint. The foot is fixed in a marked valgus attitude and there is often a backward dislocation of the ankle joint. The medial malleolus is prominent and the tendo calcaneus contracted. Pain is severe and continuous and eventually the foot may be rendered quite useless.

Radiological investigation will demonstrate that the line of articulation between the tibia and the talus slopes obliquely downwards and medially instead of being horizontal.

Bad positions after ankle fractures are often due not so much to failure to correct the primary displacement as to too early and unprotected weight bearing. If the patient is allowed to walk before firm consolidation has occurred the soft callus gives way and the foot reassumes the everted attitude and usually shows some backward displacement as well. There may be a surprising amount of ankle joint movement but in most cases dorsiflexion is greatly impeded.

TREATMENT

If the displacement is slight and particularly in older people a simple leather arch support with an ankle corset may relieve the pain and provide enough support to enable them to walk. In patients of suitable age and condition any severe degree of mal union should be corrected by open operation.

Operative Treatment

In the typical Pott's fracture with eversion of the foot and a fracture of both malleoli an osteotomy of both malleoli allows full correction to be made with considerable hope of good function.

Where the lower end of the tibia has been broken and dis-



FIG. 38.—Mal union of a Pott's fracture.
(a) Backward displacement.
(b) Late valgus displacement.

placed outwards, as well as the lower end of the fibula, a double osteotomy in the line of the fracture may solve the problem

The difficult type of tri malleolar fracture where the posterior surface of the tibia is broken off and the astragalus, fibula and posterior tibial fragment displaced upward, may in recent cases be treated by lengthening the tendo Achilles, pulling the foot downwards and forwards and nailing the tibial fragment in position. But in old cases it is better to fuse the tibio astragalar joint

The procedures considered in detail, therefore, are

- 1 Reconstruction of the ankle joint
- 2 Arthrodesis of the ankle joint

Trethowen believes that the decision rests on the age of the fracture, the age, occupation, and general condition of the patient, and the

extent to which weight has been transmitted through the deformed ankle. If, for example there is a considerable amount of traumatic arthritis, a reconstruction is less likely to succeed than an arthrodesis. Again, reconstruction is usually not undertaken after an interval of six months from the date of the fracture

The aim in performing a reconstruction is to secure freedom from pain and a fair degree of ankle movement. If this can not be guaranteed, it is

better to arthrodesise the joint and ensure a painless ankylosis. A final decision as to the choice of operation may be possible only after the joint is exposed at operation

1 Reconstruction of the Ankle Joint Certain difficulties arise in connection with this operation

- 1 Full reduction is difficult to secure

2 The substance of the fibula at the line of fracture is difficult to restore

3 The "posterior" malleolar fracture is not easy to correct, and unless reduction is complete considerable strain is imposed on the graft or screws which are employed to fix the separated fragment

Two long incisions are used. The lateral incision follows the posterior border of the fibula downwards from a point 6 inches above the malleolus, curving forwards beneath the malleolus to end on the lateral

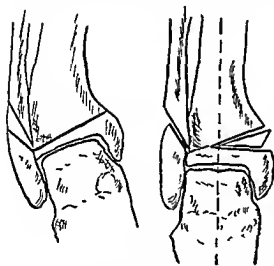


FIG. 386—Mal union after Pott's fracture—Reconstruction of the fracture

side of the foot. The fibula is then carefully divided through the site of the original fracture unless the union is only fibrous in which case the fractured ends are merely freshened. The medial incision is of the same length and is placed midway between the medial border of the tibia and the tendo calcaneus curving forwards beneath the medial malleolus. An osteotomy is now carried out through the line of the original fracture in the tibia and the bone ends freshened.

The posterior malleolus is approached when necessary between the tendon of the flexor longus hallucis behind, and the posterior tibial nerve and vessels in front. The access may be improved by plantar flexing the foot. The posterior fragment is easily separated from the tibia by detaching it first from the articular surface. To do this the mal union is accurately cut through where the line of fracture enters the articular surface of the ankle joint. The tibia and fibula are now completely stripped of all soft tissues except the periosteum for a distance of 2 or 3 inches, and delivered through the medial incision. The foot, with the freed malleolus, is now completely separated from the tibia and fibula thus complete mobility is essential for the successful reduction of the displacement.

The foot is now manipulated as in treating a fresh fracture. The heel and toes are grasped and powerful traction made in the long axis of the leg. The foot is then forced forwards by firm pressure on the heel behind while an assistant simultaneously thrusts the leg backwards by pressure just above the ankle. The foot is now displaced directly medially from the leg at the ankle joint, after which reduction is complete and it remains to select the appropriate method of retention. This may be obtained either by two vertical bone pegs through into the shaft or by plaster of Paris case.

If a gap is left in the fibula after correction it is frequently necessary to repair the defect by an autogenous graft. The tibial fragments and the detached posterior malleolus are fixed firmly in the corrected position by bone peg or nail. The foot is put up at a right angle and with as much inversion as necessary, the plaster being applied over a full dressing. The stitches are removed and a fresh plaster applied at the end of a fortnight. At this time an opportunity should be taken to make any further correction which may be shown to be necessary by an X ray film taken in the interval. An alternative procedure which may be used for older cases is depicted in Fig 386.

2, Arthrodesis of the Ankle Joint. The author uses a bone block method. A vertical incision is made over the lower end of the fibula extending from below the malleolus upwards for 5 to 6 inches. The fibula is divided in an oblique direction upwards and inwards about



FIG 387—Mal union of Pott's Fracture Arthrodesis of the ankle joint

3 inches above the malleolus and the lower fragment levered outwards and downward, so exposing the joint. If there is any displacement of the internal malleolus, it is divided at the level of the ankle joint and any lateral displacement of the talus corrected. A block of bone about 1 to 1½ inches in all directions is now cut with an osteotome on the fibular side from the lower margin of the tibia and the upper margin of the talus. This may be used entire or, divided into small pieces. If the former, it is turned round 90°, replaced in the gap after the position of the ankle joint is corrected, and punched home. When small chips are used they likewise are punched well home. The fibula is replaced and the obliquity of the osteotomy retains it in position.

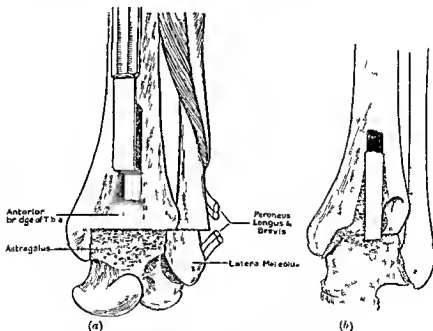


FIG. 388—Arthrodesis of the Ankle

(a) Brittain's method

(b) Watson Jones's method

A stable ankle joint is easily achieved after three months immobilization in plaster of Paris.

Since torsional movement of the foot may occur in the plaster, Watson Jones fixes the joint with a bone graft. He cuts a graft from the lower end of the anterior aspect of the tibia, turns it upside down and drives it into a socket in the astragalus. The graft is firmly wedged to the tibia by crushing home in on either side of it. Brittain suggests a similar operation but removes his graft from the tibia at a higher level and leaves an anterior bridge of bone so that the graft as it traverses the ankle joint is totally enclosed. He uses a special angled osteotome to cut the bed into the astragalus.

A simple method of obtaining fixation of the ankle joint has been described by Galland. He exposes the medial malleolus and the line of the ankle joint and drills a large hole obliquely downwards and outwards through the joint. Thereafter an autogenous graft of bone is driven through the line of the joint so as to act as a locking key.

THE PROBLEM OF THE SHORT LEG

Several operative measures have been instituted to equalize the length of the lower limbs when these are unequal. Such a procedure is of value where deformity or disease of the pelvis or limb bones has led to unilateral shortening. In addition it is of great value in cases of infantile paralysis associated with shortening where the patient has recovered a degree of muscular power which should enable him to walk were the leg not overtaxed by the heavy appliance necessary to compensate for the defect in the length.

Before any of the following expedients are contemplated the whole circumstances of the case should be carefully reviewed. No interference is warranted if the individual can in any way compensate for the shortening without grossly upsetting the body mechanics. In this connection it should be recalled that shortening up to 3 centimetres can be disguised by tilting the pelvis and without an obvious limp. From 3 to 5 centimetres of shortening can be overcome efficiently by raising the heel or the sole of the boot. Over 5 centimetres cannot be properly compensated for either by the patient or by the use of apparatus. It is in the latter type of case that the following methods find their sphere of usefulness. The following procedures have been variously advocated.

1 Operations on the Sympathetic. That panacea of all ills lumbar ganglionectomy and ramisection has been carried out on one side in order to lengthen the limb. It is supposed that increased blood supply following the operation will result in overgrowth at the epiphyseal disc on the side affected. Striking results have already been published but their accuracy is problematical since no effect on the length of the limbs has been observed by the author following this operation in Hirschsprung's disease. At present it may be said that the value of this operation has not been established, and consequently it should not be employed.

2 Bone shortening Operation. Another alternative is actually to shorten the longer leg which is usually also the sound leg. Calvé has described a plastic operation in which he shortens the fragments and retains them in position by an interlocking. The upper fragment is shortened by resection of a piece of bone in an oblique direction, leaving at the lower end of the fragment a tooth which acts as a sort of tenon which is inserted into a corresponding groove in the medullary cavity of the lower fragment or vice versa. For all practical purposes an

oblique osteotomy is equally effective the shortening being obtained by overriding the fragments

Compared with the greater complexity of bone lengthening operations, the shortening operations have in their favour the advantage of comparative technical simplicity. There is however a natural aversion to operating on the good limb and in most cases shortening operations should not be undertaken until the natural expedients for compensation are exhausted

The shortening of the long leg has been brought about by epiphyseal arrest by means of a graft or grafts of bone across the epiphyses (Phemister). As this involves careful calculation of the age at which it should be performed in order to obtain the optimum result it will be a matter of years before this result can be appreciated

3 Bone-lengthening Operations Lengthening operations are more constructive in that they aim at the restoration of the normal



FIG. 389 Lengthening of Bone. Method used in lengthening of a short femur after the method of White

After a Z-plasty of the femoral shaft a graft is inserted through the retractor later from before the legwards and another laterally above the femoral condyles. A rectal alginate is now applied to separate the two sections into four turnuckles. The femur is then pulled apart by the turnuckles. This case was lengthened two inches.

length of the affected leg. Collivilla has shown that the shortened soft structures retain a great deal of elasticity and appreciably lengthen when traction is applied after the bone is divided. The principle of skeletal traction therefore, offers a good prospect of a satisfactory result provided the traction is not overdone. Before a bone lengthening operation is undertaken the inherent elasticity of soft structures must be estimated as the limit to which they stretch will determine the amount of lengthening which can be expected. In this respect the structures to be most considered are the vessels and the nerves.

The method employed involves division of the bone and the site of the osteotomy varies with the causative lesion but the femoral shaft is usually chosen. If the shortening has followed a fracture it should be situated at same distance from the site of the injury but if the shortening is due to some other cause the middle of the diaphysis of the femur should be selected.



FIG 390 (a)



FIG 390 (b)



FIG 390 (c)

Fig 390 —Leg lengthening Operation (a) Traction by means of pins and sectional plaster (b) The lengthened femur in plaster until union is complete (c) Femur now united and three inches added in length

An incision about 20 cm in length, is made on the antero lateral aspect of the thigh in a line from the greater trochanter to the lateral condyle of the femur. The femur is exposed and a portion of its circumference completely denuded of all soft tissues, a self retaining retractor being inserted to hold the muscles apart. The periosteum is then incised and a Z shaped osteotomy is performed. The long middle limb of the Z is made with a large rotary saw about 4 inches in diameter the plane of the cut being in either the frontal or sagittal plane. After the long incision is completed the transverse cuts are added. The lateral is made by a small rotary saw while the medial is best done by a Gigli saw, care being taken in both cases to avoid injuring the periosteum. When the osteotomy is completed the resistance of the soft parts must be overcome by traction, but before this is applied one or two thick strands of kangaroo tendon should be tied round the fragments at either end to prevent any gross lateral displacement. For a similar purpose Putti employs an instrument which he has called the osteotome. Two pegs are first inserted into the bone at suitable distances above and below the osteotomy. The upper peg is usually set in the sub trochanteric, and the lower in the supra condylar region. After the bone has been divided, the two pegs are fitted to the osteotome which consists of a strong spring contained in a metal case and having an indicator which denotes both the amount of separation and the amount of force applied. The apparatus serves as a traction apparatus as well as an immobilizer of the fragments.

The author has used the method of White. Pins are inserted antero posteriorly through the great trochanter and laterally through the condyles. A sectional plaster is then applied to the limb one section enclosing the pelvis trochanteric pin and upper fragment, while the lower section includes the leg lower fragment and condylar pin. The two sections are then joined by 4 screw turnbuckles by means of which the two femoral fragments are gradually distracted. The position of the fragments can be judged by the right-angled position of the pins. The fact of the pins being incorporated in the plaster ensures skeletal traction.

A similar operation may be carried out on the lower leg the tibia being osteotomized and the fibula divided. The interosseous membrane and other sheets of fascia are divided. The amount of lengthening obtained however, is considerably less than above the knee.

Recent writers of considerable experience prefer leg shortening operations and believe that the leg lengthening procedures should be limited to a small carefully-chosen group of patients who are either unwilling or ill able to sacrifice any fraction of their height. The lower leg site is chosen where sufficient lengthening is likely to be achieved there since complications appear to be less frequent.

LENGTHENING OF THE QUADRICEPS TENDON

Just as limited dorsiflexion of the foot may result from shortening of the tendo calcaneus so diminished knee movement may be due to shortening and contracture of the quadriceps tendon. Contracture of the tendon may follow lesions of the femur such as simple and compound fractures and osteomyelitis. It also results from fractures of the tibia and fibula and especially ununited fractures above or below the knee joint which require prolonged immobilization. Though most of these lesions are entirely extra articular yet there may be permanent loss either complete or partial of knee flexion. In addition to actual shortening of the tendon the vastus intermedius is often firmly adherent

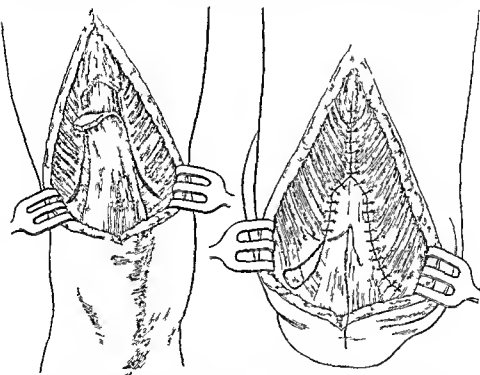


FIG. 391.—Bennett's Operation of Lengthening of the Quadriceps Tendon for Stiff Knee

to the front of the shaft of the femur so interfering with the function of the other muscles which constitute the quadriceps. Secondary changes in the capsule may occur and the supra patellar pouch is often obliterated. These errors are entirely relieved when the tendon contracture has been overcome.

In those cases where the joint stiffness is of fairly recent origin satisfactory results are often got by manipulation. This must be carried out with the greatest care owing to the danger of fracturing the patella. The method should be tried before resorting to operative means.

Bennett has described an operation which aims at freeing and elongating the tendon. He believes that it is better to operate on a patient who has walked for five years with 10 degrees of flexion than on one who has walked for only five months although there may be 30 degrees of flexion. In the former the joint and muscle tissues are in good tone and therefore lend themselves better to operation and begin to function more rapidly. It is inadvisable to operate in cases where the joint is sensitive to pressure.

Technique of the Operation. The patient lies with the knee flexed as much as possible over the end of the operating table in order to allow of free manipulation after the tendon has been released. A straight incision is made over the tendon and the skin flaps reflected to expose the attachment of the rectus and the capsule of the knee joint. The tendinous portion of the muscle is freed from the muscular part by linear incisions along each side extending from the attachment of the belly of the rectus femoris to the patella. The incisions follow closely the margin of the tendon and diverge at the upper border of the patella to leave the strong attachment of the tendon at this point undisturbed. These incisions must be sufficiently deep to include the tendinous portion of the vastus intermedius as well. The upper ends are then connected by a short transverse incision and the entire tendon is dissected downwards to the patella off the underlying structures. The knee is then carefully flexed to at least 90 degrees any adherent parts of the capsule or about the lateral margin of the knee being severed. The leg is then brought back to 80 degrees of flexion and the tendon sutured on either side to its muscles by means of kangaroo tendon or strong chromic catgut. If adhesions are present between the vasti and the lower part of the femur the muscles should be dissected off the femur to permit of their being drawn in towards the middle line for suture to the tendon. When the tendon has been thus anchored to vasti at each side a space is still left above at the lower end of the rectus. This is closed by a catgut suture still further approximating the vasti. The knee is then put up in a position of 80 degrees flexion in plaster of Paris for a period of three weeks. At the end of this period passive extension of the knee is begun during the day and the knee replaced in its flexed position on a splint at night. At the end of the fourth week active contraction of the muscles is encouraged. The leg should not be completely flexed at too early a date as the tendon may then rupture from its muscular attachment. The power of extending the leg is slow to return especially in its last few degrees in some cases it may not return for a year. Weight-bearing on the leg without suitable protection is not allowed for at least three months from the date of operation.

CHAPTER XVIII

MANIPULATIVE SURGERY

This is a branch of surgery which has been undeservedly neglected by our profession and it has in consequence fallen largely into the hands of unqualified practitioners that it should have done so is a real misfortune as manipulation properly carried out on suitable cases can be a most valuable therapeutic agent Manipulative surgery aims at restoring movement to a joint whose range of movement is limited and at abolishing the pain which is so frequently present in a stiff joint In order to restore normal movement or even merely to increase the range of movement of a damaged joint some abnormal resistance to movement must be overcome by the use of a certain amount of force during the manipulation and the degree of force necessary will be reduced to a minimum if the muscles are first relaxed by an anaesthetic

The unpaired function which is so obvious in most cases requiring manipulation may be caused not only by a lesion in the joint itself but also by some condition either of the soft tissues in the vicinity of the joint or of the muscles which activate it all these lesions can often be effectively treated by putting the joint through its normal range of movement and it is seldom necessary to exceed the normal range

ADHESIONS

The common cause of stiffness of a joint is the presence of adhesions which may be both in the joint itself and in the soft tissues around it An adhesion is a pathological band the result of an exudate produced by trauma or inflammation in the early stage it is weak and easily stretched but as fibrosis sets in it loses its elasticity and impedes the movement of the joint

Joint stiffness after injury is due to adhesion of the capsular plications which in turn is the result of organization of any exudate in the periarticular tissues In fact it is the recurrence and persistence of serofibrinous exudation which provides the key to the problem of adhesion formation

Watson Jones points out that the following factors several of which may occur in the same case are considered responsible for continued or recurrent exudation (1) disuse with continued venous stasis

(2) recurrent œdema, (3) the recurrent trauma of daily passive stretching or repeated manipulation, (4) the constant trauma of immobilization in a position of strain, (5) continued infection near a joint, and (6) the continued irritation of foreign bodies near a joint.

Immobilization in itself is not a major factor in the development of adhesions when uncomplicated by other factors. Any adhesions formed are the result of venous stasis. Once a patient resumes active use of the part, recovery of normal function occurs.

Watson-Jones emphasizes the serious disability that follows the presence of continued œdema in a limb which is immobilized. "There is no more potent factor in adhesion formation, for œdema is the glue of which adhesions are made." Swelling is controlled by external pressure and active muscle exercise. He particularly denounces passive stretching and exercise, since such therapy results in a continual recurrent traumatic exudation, with the formation of fresh adhesions.

Extra articular adhesions which may be connected with the capsule, the ligaments, or the muscles, are the result of old organized blood clots or effusions following trauma, they are just as liable to produce limitation of movement as are intra articular adhesions, and in time are followed by adaptive shortening of the muscles and other soft structures.

Intra articular adhesions may be caused by synovitis, or arthritis, but those usually treated by manipulative surgery are the result of trauma which produces a sprain of a joint. This sprain occurs when the muscles are taken unawares and the joint is forced to the extreme limit of its normal movement, or a little beyond, so that the force, continuing, stretches the ligaments, it is actually a rupture of ligaments, usually in a minor degree, a few fibres being separated or torn, with, as a result, slight hæmorrhage and exudation of fluid. This is followed either by complete resolution and return to normal, or by the formation of new fibrous tissue and scarring at the site of the injury. When the acute process has subsided it may be found that part of the ligament has become thickened and contracted, so that a movement which puts it on the stretch is restricted, such a condition is commonly spoken of as "adhesions."

DIAGNOSIS OF ADHESIONS

The diagnosis of traumatic adhesions is of considerable importance, and in particular they have to be differentiated from the presence of arthritis. The differences between the two conditions can be set out most suitably in a tabular form (see next page).

The difference in the limitation of movement is one of the most important points in the differential diagnosis, and provides a safe and practical rule for treatment by manipulative surgery, but it must be remembered that this distinction does not apply in cases of septic infection involving the tissues, nor to fractures within the joint.

| Signs and Symptoms | Adhesions | Arthritis |
|--------------------------|--|---|
| 1 Limitation of movement | Only those movements which put affected ligaments on stretch All others free | All movements limited to some extent |
| 2 Pain | (a) Localised and occurring when adhesions are stretched (b) Maximal when joint is moved (c) Less severe when joint surfaces forced together | (a) Diffuse (b) Maximal when bony surfaces are forced together |
| 3 Tenderness | Can be localized by pressure | Diffuse |
| 4 Stiffness | Stationary or retrogressive | Progressive, |
| 5 Muscular wasting | From disuse only | Greater than can be explained by disuse alone |
| 6 Temperature of joint | Unaltered | Usually raised |

The differential diagnosis is completed by means of an X-ray examination, and indeed the joint should always be X-rayed in any case either of disease or injury

The Choice of Cases for Manipulation

The main conditions which call for manipulative surgery are (1) dislocation, (2) adhesions which require to be ruptured, (3) certain conditions of the soft tissues, (4) joints which are not absolutely dislocated but which are the seat of some defect difficult to describe and to which Mennell gives the name "seized"

In all these conditions manipulation is directed towards a joint whose range of movement is limited by some abnormal resistance, the manipulation overcomes that resistance and either completely or partially restores the normal mobility of the damaged joint

The difficulty in manipulative surgery lies not so much in carrying out the manipulative procedure as in deciding upon the indications for carrying it out. It is obvious that there are many pathological conditions associated with limitation of movement in which it would be useless or dangerous to carry out manipulation, the outstanding

example of this being tuberculosis of a joint obstructions which result from mal united fractures and exostoses are also definite contra indications to forcible movement With the possible exception of certain straightforward cases of foot strain no joint should be manipulated without previous X ray examination which will eliminate unsuitable cases of joint disease gross bony obstructions loose bodies fixed joints advanced osteo arthritis and myositis ossificans

Contra Indications

Manipulation should not be performed in the presence of active disease of a joint and even where an acute arthritis appears to have settled down it may have harmful effects for the resisting power of the joint may be lowered and the slightest injury may be sufficient to light up a sub acute infection Where the original arthritis was secondary to some focal infection the focus should first be removed and manipulative treatment carried out afterwards Whether an infective process is active or not can be determined by the pain elicited on moving the joint if the condition is purely traumatic pain will occur only on movement and will be of the nature of a sharp stab which is soon over if however an infective process is at work there is liable to be a continuous indefinite aching without any apparent cause or a dull throbbing pain almost unknown in purely traumatic conditions and any pain definitely caused on movement is at first sharp in character and then slowly subsides Some cases of adhesions are unsuitable for manipulation either because the adhesions are themselves too strong to be broken down by manipulation or because of the risk of producing a fracture or in some cases a combination of these two factors In fractures of the lower end of the femur with a stiff knee the adhesions may be extremely dense and if the quadriceps muscle or the patella is fixed to the front of the femur it is very easy to fracture the patella during the manipulation Similarly in an old fracture of the upper end of the humerus the adhesions may be so strong that under manipulation the neck of the humerus itself gives way before the adhesions It is well to remember that when a limb has been fixed in a plaster of Paris case for any length of time there is often a considerable degree of disuse atrophy of the bones which are consequently easily fractured one has seen a fracture of the upper end of the femur produced by attempting to reduce a congenital dislocation of the hip where a previous attempt had failed and the patient had spent the intervening period in a plaster case

As a rule the rigid arthritic joints that are met with in elderly people are better left alone as Bankart has pointed out grey hair and stiff joints are an unfavourable combination

Manipulation is not called for in children partly because of the risk of epiphyseal injury but more especially because of the marked tendency to spontaneous cure

Morton Smart points out that the chief of the contra indications to the manipulation of a joint is the presence of tuberculous disease

The other main contra indications are active infective processes, bone over growth from any cause (such as after fractures), advanced osteo arthritis, myositis ossificans, bone cysts and bone tumours. Great caution is required in cases where bones show considerable radiographic translucency from disuse and where the patella is adherent after fractures of the femur, and in the case of the shoulder after fractures extending into the joint. Any erosion of cartilage or the presence of a loose body should as a rule be a contra indication to manipulation.

Conditions in which Manipulation is of Value

Mennell has pointed out that manipulative procedures may be successful if active pathological processes have ceased, or are quiescent, if the limitation of movement is due to adhesions, if the limitation is due to the locking of two joint surfaces upon one another, and if the manipulation is performed with a skill that will lay no undue strain upon a normal structure, whether an intrinsic part of the joint or not. He points out, too, that there may be a slight displacement of joint surfaces without an active dislocation, he says that most people have experienced sudden pain in a joint on extreme or unexpected exertion, they check the movement at once, and if possible, shake the part and get instantaneous relief. In some joints, however, this relief cannot be obtained voluntarily, as the joint may not be accessible, or amenable, and then manipulation becomes necessary. It is suggested that the only possible explanation of such an occurrence is that the joint surfaces have "seized up" to use an engineering expression, and are freed by their subsequent manipulation. Some joints are more subject to this than others, as for example those between the proximal and distal rows of metacarpal bones in the common form of "tennis wrist," a condition easily remedied by manipulation.

The cases most suitable for manipulation are those with limitation of joint movement produced by fibrous tissue adhesions following injury, they are undoubtedly benefited by manipulation, and, it must be added, by nothing else. Manipulation is valuable in the later stages in the treatment of fractures of the limbs where the joints have become stiff as a result of immobilization. In this connection one would point out that prolonged rest of a healthy joint rarely gives rise to more than a temporary stiffness, which, though sometimes more intractable in older people, is easily overcome by passive movement in adolescents and young adults, but that where the prolonged rest is part of the treatment of a fracture in the neighbourhood of a joint, quite considerable stiffness may follow, probably a reaction to stretching or tearing of the joint capsule and ligaments. Some rheumatic joints, whether they be the site of osteo arthritis or rheumatoid arthritis, are also improved by manipulation, but when to institute this treatment in such cases is a most difficult decision to make. It is not possible to say whether ionization, diathermy, or other form of radiation will be most beneficial in any given case, but they should all be

tried in turn, and if none prove successful then manipulation should be considered. Forced manipulation should never be undertaken whilst the joint is acutely inflamed, but only when the joint has recovered from the disease. Broadly speaking, recovery can be said to have occurred when the range of movement of the joint is not diminished by use. If the movement of the joint is restricted to a certain range by fibrous ankylosis, and this range is further reduced when the joint is used, we know that recovery has not taken place, and that manipulation would be disastrous, but if the joint shows an increasing range of movement following function then in all probability it is free from active disease.

Prevention of Adhesions

In order to prevent the formation of adhesions any inflammation that may be present is allayed, local effusions are prevented by pressure, injured structures are massaged early, and movements that place no strain on the injured soft tissues, especially active movements, are practised, and the early active function of the joint encouraged. Injured joints should be immobilized in the semi-flexed position, as stiffness develops more readily in the extended than in the flexed position, and also because when the joint is eventually mobilized a start may be made in both directions, whereas if the joint has been immobilized in extension all the increase in movement must be made in one direction. Fractures of the elbow, knee and ankle joints are usually united sufficiently in from three to four weeks to permit of gentle movement.

Treatment of Adhesions by Manipulation

Adhesions should be prevented from forming by early active movement, but once present they should be broken down little by little, or more forcibly under an anaesthetic. The force that may be used in particular cases can be gauged only by experience, one may put all one's force into the manipulation of an adult foot, and the manipulation of a spine also requires a considerable amount of strength, the strength of the adhesions, the size and build of the patient, the age and sex of the patient in relation to the probable strength or brittleness of the bones and the effect of previous immobilization and probable atrophy of the bones, must all be taken into consideration.

Manipulation fails most often through faulty technique, that is, failure to manipulate with sufficient force and in the right direction, inexperience, fear of accidents, and imperfect muscular relaxation, are responsible for many of the failures and inadequate after-treatment accounts for not a few others.

In attempting to break down non-arthritic adhesions muscular resistance must be eliminated before the passive resistance of fibrous adhesions can be estimated accurately, and this is the most important indication for an anaesthetic, although it is desirable also to avoid

unnecessary pain Full anæsthesia is essential when dealing with old and strong adhesions, as manipulation can only be performed thoroughly when the muscles are completely relaxed, gas and oxygen therefore, is a rule only possible for recent adhesions though the quick recovery of consciousness after it means that the patient can be made to move his joints all the sooner after the manipulation, and this has an excellent moral effect

As manipulation in most cases consists in forcibly moving a joint so as to stretch and tear the adhesions, we must know what the normal range of movement in the joint should be, this can be ascertained by putting the joint on the normal side through its full range. A different amount of force is required in different joints and even in the same joint in different cases and the amount of force which may be employed with safety in the movement, and the extent and direction in which to move the joint, are learned by experience, it cannot be measured or described but it is the least possible consistent with obtaining the desired movement and must be of a carefully guarded nature. After the joint has been carried to the extreme limit of movement, an attempt is made to carry it a shade further, and the hand making the attempt will probably travel through only a very small space. After the joint has been conducted once through this range, we should be satisfied it is unnecessary to repeat it. The limb is then placed in the position of full correction while the patient is still unconscious so that he may awake with the limb in the corrected position. If the manipulation has been very severe and reaction is feared, the joint may be rested for a day or two massage being employed instead of movement. The position of the joint while resting is such that the adhesions are lengthened, in other words, the improvement in movement produced by the manipulation is maintained.

In most cases of traumatic adhesions the manipulation is completed at one operation and the full range of movement obtained, but when adhesions are very extensive and particularly in rheumatic cases in which a considerable reaction may be anticipated, it is unwise to try to obtain full movement at one operation, and it is preferable to manipulate in stages in conjunction with physiotherapeutic treatment. The tearing of the adhesions is accompanied by an audible snap or crunch, while the sensation imparted to the experienced operator's hand is unmistakable and is sometimes remarkably like that felt on fracturing a bone by hand. The tearing of fibrous adhesions is followed by an inflammatory reaction, which tends to the reformation of further adhesions if the part is kept at rest during the process of healing. If there is much effusion after a manipulation, firm bandaging over cotton wool is applied to the joint, and massage and movements are started the day after the manipulation and continued until the joint is normal. The massage must be very gentle where there is great pain and tenderness, and as soon as possible active movements are encouraged by the masseur

THE TREATMENT OF INDIVIDUAL JOINTS

1 The Foot

The foot requires manipulation more often than any other part of the body since there are so many cases of foot strain. The natural foot should be so supple that it can be completely flattened or raised into the form of an arch at will. Where there is some postural deficiency, so that the muscles fail to support the body weight adequately against gravity, we get symptoms of foot strain in which the most characteristic pain is referred to the region of the talo navicular joint. The mobility of such a foot varies greatly in different cases, but in most there is some obvious resistance to passive movement and pain is produced when the movement is forced, this resistance is no doubt due to chronic adhesions around the mid tarsal joint, and it is the stretching of these adhesions that is responsible for the pain. The pain therefore occurs when the body weight is thrown on the foot and stretches these mid tarsal adhesions which are preventing the arch of the foot from flattening out as it should do.

There are two ways in which this strain on a resistant foot may be prevented, one is to prevent the foot from flattening, the other is to enable it to flatten without resistance, in other words to break down the adhesions. The all important movement, therefore, is in the direction of abduction and eversion, so as to flatten out the arch and overcome to the utmost the resistance to this movement.

Method of Manipulating the Right Foot 1 The heel is held in the palm of the right hand, with the hand resting on the table. The left hand grips the dorsum on the outer side of the foot and first plantar flexes and then forcibly adducts and inverts the foot with a combined twisting and pushing movement.

2 The heel is held in the left hand. The right hand grips the dorsum of the foot and forcibly abducts the fore part of the foot while keeping the foot extended. Thereafter, the sole is everted with a powerful twist.

3 The heel is held in the right hand while the left grips the forepart of the sole of the foot across the line of the metatarsal heads, with the thumb on the outer border the fingers on the inner border, and the palm of the hand against the ball of the foot. With all the weight of the shoulder, the foot is forcibly dorsiflexed and at the same time the sole everted the knee being held down by an assistant to prevent its flexing suddenly.

AFTER TREATMENT The object of the after treatment is to restore or increase the mobility, and to counteract wasting and loss of tone in the muscles. All movements should be fully performed, passively if necessary, but actively as soon as possible. A wedge, $\frac{1}{4}$ inch thick, should be applied to the inner side of the heel of the shoe so as to relieve the muscles from strain, but the inner side of the sole should not as a rule be raised.

2 The Knee Joint

The conditions for which the knee joint is commonly manipulated are chronic sprains and derangements of the cartilages. Chronic sprain results usually from some abduction trauma of the leg or from a slight degree of rotatory movement which if it went far enough would tear the cartilage. This condition is not unlike an actual injury of the cartilage but is milder in degree and unaccompanied by locking of the joint. The trauma is followed by a sharp pain then by some swelling of the joint loss of tone and wasting of the quadriceps and a tendency for the knee to give way. On examination there is little to be made out except the wasting of the quadriceps and movements are free and apparently full. Pain may be complained of on the inner side of the joint line on rotation of the tibia and tenderness is frequently elicited over the inner side of the joint line a little in front of the internal lateral ligament or over it.

The treatment of this chronic knee sprain is manipulation under an anæsthetic followed by massage exercises and faradic stimulation to the muscles. A general anæsthetic is given and complete relaxation produced. To break down the adhesions the knee is fully flexed and in that position the leg is rotated out and in.

1 The knee is fully flexed until the back of the leg touches the thigh. This is completed by a short sharp jerk of the leg towards further flexion and in many cases an audible click or crack will be produced.

2 An attempt is made to pull or push the head of the tibia forwards on the femur. This is best done by putting the forearm into the angle behind the knee and using the forearm as a fulcrum trying to lever the head of the tibia forwards by flexing the knee over the forearm. Alternatively the knee is again flexed over the surgeon's forearm which is placed in the popliteal space and the tibia is then pulled slightly forwards by means of the forearm.

3 With the knee flexed to a right angle the surgeon grasps the leg above the ankle with one hand and the head of the tibia directly with his other hand while an assistant steadies the thigh and the tibia is then forcibly rotated first in one direction and then in the other using both the grip of the hand and the swing of the body for the movement.

4 Standing at the foot of the operating table the surgeon puts the patient's heel on his shoulder and after clasping his hands over the front of the knee he pulls down the joint into full extension with one or two short sharp jerks. This grip gives the most powerful pull and the most complete control of the movements.

5 If the adhesions are in front of the joint the knee should be flexed while the hip joint is hyper extended in order that extra tension may be put upon the structures in front of the joint. In these cases flexion is carried out with the patient in the prone position.

If after an injury a patient is unable to extend his knee fully we

may suspect either an *unreduced semi lunar cartilage* or, more rarely, a fracture or evulsion of the tibial spine which may be clearly seen on an X ray film. A *displaced semilunar cartilage* may be reduced by manipulation even if some months have elapsed since the injury. The chief obstacle to reduction is muscular spasm which holds the bones tightly together, gripping the cartilage between them. In the case of the internal cartilage, the knee should be flexed and the tibia rotated inwards under an anæsthetic, then abducted during extension. In dealing with the external cartilage the tibia should be rotated outwards and adducted. It is sometimes possible without an anæsthetic to trick the muscles since the extensors and flexors are not in spasm together and there is a short period during the change from extension to flexion when each group of muscles is passing from contraction to relaxation or vice versa at this moment they may be caught off guard or comparatively relaxed. The trick consists in performing rapidly alternating movements of flexion and extension, and in rotating the tibia simultaneously at the very moment of change from one to the other.

AFTER TREATMENT Since the cartilage rarely heals immobilization serves no rational purpose. All knees after manipulation should have a pressure bandage applied for twenty four hours to prevent or diminish swelling and thereafter massage active movements and electrical stimulation of the muscles are begun.

3 The Hip Joint

The chief conditions in the hip joint for which manipulation is used are osteo arthritis and ununited fractures of the neck of the femur with a painful adducted limb and in such cases manipulation often gives the patient much freer movement and a great relief of pain. In manipulating the joint is moved in all directions but, where there is any osteo arthritis not through its full range but merely until *adhesions* are felt to give way. Under a general anæsthetic the limb is grasped at the mid thigh level with one hand and below the knee with the other and the thigh moved until the movement is felt to be checked. An endeavour is then made to estimate the degree and nature of the resistance, if solid it should be strained but not forced, but if it yields, movement is continued until the limit of safe movement appears to have been reached. In this way all the movements of the hip are dealt with in turn ending with circumduction. It is dangerous to use the leg as a long handle at a right angle with the thigh, since this long leverage may easily produce a fracture.

4 Low Back Pain

The condition in this region which is most amenable to treatment by manipulation is a strain of the sacro iliac joint. The symptoms and diagnosis of this condition have already been described and treatment by manipulation is usually very satisfactory, though a proportion of cases are not cured by this method and require operative means.

THE TECHNIQUE The patient lies upon a firm, low operating table

and is fully anesthetized. As in other joint manipulations the spine is put through its normal range of movements.

(1) *Flexion* The surgeon and his assistant stand at either side of the table and each grips a leg under the knee and together the limbs are lifted with a swing fully flexing the hips. In this position heavy pressure is put on the back of the patient's thighs so as to flex the pelvis on the lumbar spine to the fullest extent.

(2) *Rotation* The assistant holds down the shoulders while the surgeon standing on the right hand side of the table rolls the pelvis over towards him. The left leg is brought down over the right side of the table and the left iliac crest forced by sudden sharp movements down on to the table. With the surgeon standing on the left side of the table the movement is repeated in the opposite direction and by these means considerable rotation of the spine is effected.

(3) *Extension* The patient is turned on his face and the surgeon and his assistant place their forearms under the thighs and lift the thighs up. Their other hands are then put over the lower lumbar spine and keeping the elbows straight they give a sudden jerk in this position which produces a degree of hyperextension of the spine.

AFTER TREATMENT There is rarely much reaction and so massage and exercises are begun the following day and are continued for a month or longer. In this way the lumbar spine and sacro-iliac joints are mobilized. It may be necessary in older cases to manipulate them more than once before they are cured. Cases which resist this treatment may be cured by arthrodesis after the manner of Smith Petersen already described.

5 The Shoulder Joint

In manipulating the shoulder especially in the aged great care is needed since it is not difficult to produce a fracture or a dislocation either when rotating the humerus laterally or when abducting it. The patient lies on his back with the injured shoulder projecting over the edge of the table and he should be fully anesthetized as complete muscular relaxation is a necessity. A short leverage is preferable to a long one so the arm should be gripped at the mid shaft of the humerus and not at the elbow. In manipulating a right shoulder the left hand of the operator steadies the shoulder girdle while the right hand grips the middle of the humerus with the elbow of the patient flexed over the operator's forearm. The arm is rotated inwards and outwards and then completely adducted and abducted. In the fully abducted position it is again rotated inwards and outwards. The scapula is next released and allowed to move with the arm while it is fully elevated in which position full rotation should be carried out so that the forearm can easily be placed behind the back and behind the neck. The arm is then circumducted while being brought down to the side. Finally the arms are elevated and the hands placed behind the head and from this position the arm is pushed backwards the head of the humerus stretching the front part of the capsule. If

adhesions are very firm these movements may have to be done in stages but if possible they should be completed at the one time

Mennell has pointed out the importance of putting traction on the adducted arm so pulling the humerus downwards and thereafter pressing the head of the humerus into the glenoid cavity and again carrying out the various manipulative manœuvres with the head in that position.

6 The Elbow Joint

In breaking down adhesions about the elbow joint care is needed lest damage be done to the joint or the bones forming it. If the adhesions are recent and unaccompanied by fracture the joint is put through its complete range of movement but if they are firm and associated with a fracture or following a dislocation mobility should be brought about in stages. The joint is first extended to the point of safety which is estimated by the degree of resistance it offers and then flexed using only slight force. The arm is then slung in flexion and kept in that position for two or three days after which it is extended and kept in extension for a couple of days. If no reaction has taken place the sling is removed and active movements allowed and if the range of movement increases with use no matter how slowly neither passive nor forced movements should be allowed. Following fracture in an adolescent especially if incompletely reduced the elbow may assume an angle of about 40 degrees from full extension and there may be a considerable degree of reaction and even inflammation if the joint is roughly handled. This can be avoided if the elbow is flexed without much force until strong obstruction is met with and then kept slung in its new position for a few days after which it is found easy to obtain further flexion of 10 or 20 degrees. *this may be repeated two or three times. In cases of stiff elbow it is wise to* exclude myositis ossificans by X ray films before attempting any manipulation as movement of any kind is contra indicated in these cases the correct treatment being prolonged immobilization of the elbow until the new bone has become absorbed or dense and well defined.

A special manipulation is used in cases of tennis elbow. The procedure recommended by Bankart is first to pronate the forearm and flex the wrist then keeping the wrist fully flexed to extend the elbow fully with a short sharp jerk. This effect may also be obtained by reversing the order of these movements as follows first fully extend the elbow joint with the forearm in a position midway between supination and pronation then keeping the elbow extended simultaneously complete the pronation and fully flex the wrist with a quick forcible movement. This manœuvre is more likely than the first to stretch the extensor muscles at their origin from the humerus. It is also useful to hinge the extended elbow forcibly in an ulnar direction and in this way further stretch the extensors.

7 The Wrist Joint

Manipulation is not often called for in the wrist joint but immobiliza-

tion of the joint following a sprain may lead to much stiffness from adhesions about the strained ligaments. Often after the stiffness appears to have gone the patient still complains of pain and weakness of the hand and it is found that the extremes of flexion and extension are limited and painful. In these cases manipulation under an anæsthetic is indicated since full movement may be restored by putting the wrist joint through its normal range of movements.

CHAPTER XIX

ARTHRODESIS AND ARTHROPLASTY

ARTHRODESIS

Arthrodesis is the term applied to the artificial or operative production of ankylosis in a joint. In performing the operation usually the whole joint cavity is obliterated and the bony components brought into apposition eventually they unite and with the establishment of bony continuity all trace of the original joint is lost.

Arthrodesis may result in the complete eradication of certain diseases or may be employed as a method of stabilizing unstable joints.

Its curative function is exercised in virtue of the fact that the diseased tissues are more or less completely ablated. In tuberculosis for example the removal of as much diseased tissue as possible and the approximation of the bone ends renders the tuberculous focus entirely intra osseous and a decided step is thus made towards the natural elimination of the disease. In other types of inflammatory affections e.g. rheumatoid arthritis and post-traumatic arthritis the fixation of the joint may also result in the cessation of the inflammatory process.

Its stabilizing function is of most importance in the treatment of those affections which terminate in flail joints not only does arthrodesis restore stability but at the time of operation any deformity can be corrected or potential distortion prevented.

The symptomatic indications for arthrodesis are in brief

- 1 Persistent pain and
- 2 Loss of function with or without deformity

The principal conditions which produce these are

- 1 Arthritides of various types including tuberculosis
- 2 Trauma particularly fractures involving joint surfaces or fracture dislocations
- 3 Paralysis usually anterior poliomyelitis but sometimes a peripheral nerve injury

These will now be considered in more detail

1 Arthrodesis in the Various Types of Arthritides

(a) *Tuberculosis* In tuberculosis operations designed to ankylose the joint are restricted usually to adult cases since in childhood arthro-

desis is apt to lead to interference with the subsequent growth of the bone, and, therefore, of the limb

Regarding the stage at which arthrodesis should be undertaken, it is well to bear in mind that during the active phase of the disease an ordinary intra articular arthrodesis may not be followed by bony ankylosis, the operation should be postponed, therefore until the disease has been rendered inactive by a prolonged period of conservative treatment, and the final decision as to its suitability must rest on the radiographic and the clinical appearances of the affected joint

In many cases of joint tuberculosis the operation is carried out by the extra articular method. This has as its aim the fixation of the joint without opening the joint cavity and without interfering with the joint surfaces, and, though these aims may not be fulfilled since the capsule has often to be opened, there is nevertheless considerably less disturbance of the diseased area than in the frankly intra articular type of operation

The spinal osteo synthetizing procedures are, in actual fact extra articular arthrodeses in the truest sense of the term, and in the hip also a completely extra articular fusion can be carried out

Arthrodesis can also be usefully employed in the type of tuberculous joint that heals by fibrous ankylosis in bad position. In fact, in such a case it should be carried out whenever possible, as a corrective osteotomy is liable to precipitate a relapse

(b) *Infective Arthritis* Joints which as a result of infective arthritis have been left crippled and painful, with limited movement and bad function are best treated by arthrodesis but before the operation is undertaken the surgeon must be certain that the active infective process has been completely eradicated

The operation is also applicable in cases of rheumatoid arthritis of the hip or of the knee

(c) *Neuropathic Arthritis* Fusion is a beneficial procedure in a Charcot's joint as it stabilizes the limb and obviates the necessity for controlling apparatus. It can usually be carried out in the knee joint, and occasionally in the ankle

2 Arthrodesis for the Sequelæ of Trauma

The value of arthrodesis in the treatment of arthritic pain following fractures which involve the articular surfaces cannot be over emphasized. Such pain is especially common in the ankle region where mal union is frequent and where the mal union has been followed by the development of arthritis the value of the operation is enhanced. The severe disability which results from fractures of the calcaneus can be practically eliminated by the operation of sub taloid arthrodesis, and indeed, Wilson advocates its employment as an immediate measure in all cases of fractured calcaneus where the displacement is gross

Crush fractures of the vertebral bodies may be followed by severe and persistent pain, despite treatment by prolonged recumbency and the application of a well designed brace, and in those cases a fusion operation will probably alleviate the disabling symptoms

3 Arthrodesis in Paralysis

When a joint has been rendered completely flail after an attack of anterior poliomyelitis the function of the limb can often be considerably improved by arthrodesis. The method is of great value in flail shoulder for example but the operation must be followed by careful after treatment in particular the arm should be kept abducted at a right angle for eight or nine months or even longer. Operative failures are usually due to the non fulfilment of this essential requirement the arm having been allowed to sag slowly down.

Arthrodesis may occasionally be of value in certain cases of spastic paralysis. In spastic drop wrist for example an arthrodesis will substantially improve the usefulness of the hand.

Arthrodesis in the Various Joints

The Hip Joint

Arthrodesis of the hip may be employed either for stabilizing a weak joint or obliterating a diseased one. It is applicable therefore to tuberculosis to the flail joint which follows anterior poliomyelitis to old standing cases of congenital dislocation to unreduced traumatic dislocations and to painful osteo arthritis.

There are two well recognized methods of carrying out the operation—the intra articular and the extra articular though in many cases a McMurray osteotomy gives better and more certain results.

The Knee Joint

The indications for stabilizing the knee are essentially the same as for the hip joint although it is questionable whether the operation should be undertaken in cases of paralysis since the knee can be controlled very efficiently by mechanical apparatus of the walking-caliper or the knee cage type. Arthrodesis of the knee is more difficult in children than in adults and it should be further borne in mind that while a knee joint ankylosed in extension is serviceable for walking it is a considerable handicap when the patient desires to sit. Kleinbock indeed refuses to arthrodesise a knee joint until after the age of 14 years and even then the possibilities are first explained and the final decision left entirely to the patient. In his experience relatively few prefer arthrodesis to mechanical appliances.

For all practical purposes arthrodesis of the knee finds its greatest sphere of usefulness in tuberculosis and in destructive arthritis (q.v.).

The Ankle Joint

In contradistinction to the knee joint arthrodesis of the ankle is the operation of choice for paralytic derangements as stability can rarely be secured either by tendon transplantation or mechanical appliances. Frequently arthrodesis may with advantage be supplemented by tendon transplantation.

Stability is the most important requirement of the ankle joint and takes precedence over that of movement. If complete stability there

fore cannot be obtained the operation is not only valueless but harmful. Before the ankle joint is arthrodesed the condition of the other weight bearing joints of the limb should be investigated. It is essential that these be in a position to co operate and many cases of ankle deformity otherwise suitable for arthrodesis will be best left alone if the hip and the knee joints are in any way abnormal.

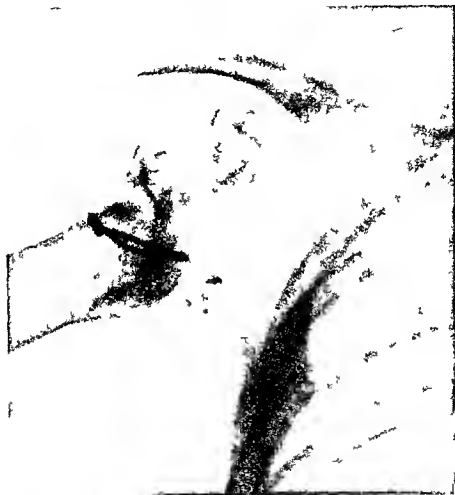


FIG. 39 —Arthrodesis of the Shoulder. The acromion has been fractured and flexed down on the humerus.

The various methods of fixing the foot and ankle are discussed in detail in the chapters on Polomyelitis and Tuberculosis. Formal arthrodesis of the ankle joint alone is often employed in cases of mal union following fracture about the ankle and is described on page 819.

The Shoulder Joint

At the shoulder arthrodesis is employed principally in correcting the flail joint of anterior poliomyelitis. As alternatives to the opera-

tion various types of tendon transplantations have been devised to restore mobility to the paralysed shoulder but these are often unsuccessful as it is often impossible to transpose the muscles to a new humeral attachment without endangering their blood and nerve supply. Fortunately however the scapula is endowed with strong and active muscles and when the scapulohumeral joint is ablated the limb retains a considerable range of movement in virtue of those muscles the movement now occurring between the scapula and the chest-wall. The muscles of greatest importance in this connection are the trapezius and the serratus anterior and unless they are acting normally the operation is doomed to failure.

Arthrodesis of the shoulder should not be carried out under the age of 10 but thereafter it should be performed as soon as possible in order to preserve to as great a degree as possible the development of the scapular the arm and the forearm muscles and so conserve the function of the arm.

Occasionally the operation is employed in tuberculosis but co-existing pulmonary infection may be a contra-indication. The extra-articular method of Britain is now most commonly used after the acute phase has subsided (see p. 354).

The Intra-articular Operation. A vertical straight incision about 6 inches long is made over the front of the shoulder joint with its centre at the tip of the acromion process. The edges are widely reflected to expose the upper part of the humerus the clavicle and the acromion process. The deltoid is separated from the latter two structures and turned down and the anterior surface of the shoulder joint now presents. The capsule is incised by a longitudinal incision and a further transverse cut is made round the glenoid cavity. The capsule is widely retracted and the whole of the glenoid cavity and the head of the humerus come into view. All the cartilage is removed from the glenoid cavity and from the head of the humerus. To denude the humerus thoroughly the head is pushed through the capsular incision and thence through the wound. The denuded articular surfaces are then adapted to fit each other in the position of abduction. The lower surface of the acromion process is now freshened and also the lateral surface of the head of the humerus. After fracturing the neck of the acromion the joint surfaces are fitted together and secured by kangaroo tendon sutures inserted through holes drilled in the head glenoid and acromion.

Bruce Gill and Watson Jones suggest a useful modification of this operation. Both upper and lower aspects of the acromion are sawed and then a broad flap of bone is raised from the outer surface of the upper part of the greater tuberosity (see Fig. 393) and levered outwards but not fractured completely. The clavicle and the neck of the acromion are then fractured and the whole acromioclavicular mass is angled downwards hinged at the part where the bones were half fractured and wedged under the humeral flap.

The wound is closed in layers and a plaster cast applied which encases the arm and forearm and reaches from the shoulder to the pelvis. The shoulder is placed in the position of maximum functional utility, i.e. abduction of 75 degrees with the elbow joint on the same plane as the anterior surface of the body, and with the forearm slightly above the horizontal, corresponding to slight lateral rotation of the humerus. The stitches are removed in a fortnight's time and a new,

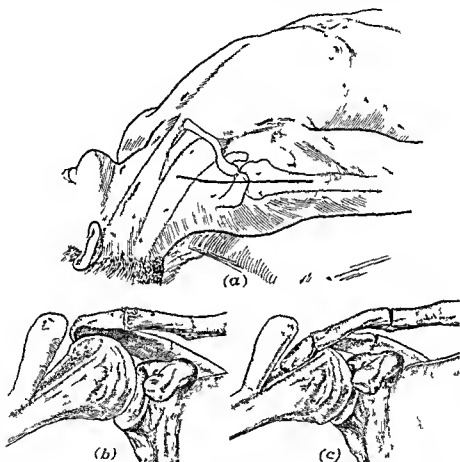


FIG 393—Arthrodesis of the Shoulder

(a) The incision (b) The acromion and the clavicle are fractured and a wedge of bone raised from the humerus (c) The fractured parts are bent down and covered by the humeral segment

more or less skin tight spica applied, this is a more closely fitting one since, as the wound is healed fewer dressings are necessary. If X ray shows a satisfactory position the plaster case is worn for four to six months and thereafter an abduction splint is applied for a further three to six months. When the plaster is removed, massage and muscle exercises are commenced, special attention being paid to the trapezius and the serratus anterior.

The Elbow Joint

Arthrodesis of the elbow has a limited application, it is practically impossible in children below the age of puberty, and even in adults it is extremely difficult to obtain sound fixation. It may be employed, however, in conditions which have resulted in flail elbow, such conditions include anterior poliomyelitis, gunshot wounds with extensive destruction of bone, and some cases of tuberculosis in which the joint has been rendered flail as a result of a previous excision.

Before arthrodesis is undertaken, the case should be reviewed carefully, and any possibility of muscle transplantation fully explored. Further in traumatic and arthritic conditions the excellent results which follow arthroplasty should be borne in mind before an arthrodesis is finally decided upon.

In this therefore, as in most other orthopædic manoeuvres, the requirements of the patient will be responsible for the ultimate decision as to the choice of method. In the case of arthrodesis, the choice depends on whether the patient requires a strong, stable joint, or a movable joint, this, in turn, depends partly on his occupation, and partly on his other pursuits. When the left elbow is flail, and the patient right handed, the joint should be ankylosed. In a recent case, the present author decided in view of his patient's occupation, to arthrodesis the left elbow, but the patient happened to remark that his principal amusement was playing the violin. The arthrodesis, accordingly, was not performed, since the violinist requires to change the position of the fingers of the left hand rapidly from time to time, and fixation of the elbow would have made this absolutely impossible.

The Author's Method. The usual posterior mid line incision is made and the skin flaps reflected. The triceps is detached from the olecranon and reflected upwards, care being taken to preserve the ulnar nerve. The forearm muscles are stripped from the proximal end of the radius and ulna, if possible without damaging the underlying periosteum, and the lower end of the humerus which is usually sclerosed is then completely resected. A cuff of periosteum is then reflected upwards from the end of the bone and the portion of the shaft now exposed squared off by filing. The position of the ankylosis is now decided upon, and, while it is usually impossible to obtain the desired position absolutely, yet with a certain amount of trouble a satisfactory arthrodesis, either in supination or in pronation, can usually be secured.

The position having been decided, attention is turned to the upper ends of the forearm bones. These are usually found to be fused together by a ridge of bone, or connected by strong fibrous tissue. These connections between the radius and ulna should, as far as possible, be preserved. Using a small, fine, frame saw, with a detachable blade, a square aperture is now made in the radius and ulna as near their proximal ends as possible. The lower end of the humerus

is then inserted into the gap and secured in place by a piece of silver wire. The wire should be knotted in front of the joint as in this situation it is less likely to cause pressure and consequent irritation or necrosis of the skin. The cuff of periosteum is turned downwards and sutured over the line of union to the periosteum of the forearm bones. The triceps muscle is turned back and provides an adequate muscle covering.

The arm is immobilized in a plaster case which extends from the wrist to the shoulder and chest. In about three to six months the plaster is removed, the stitches cut and a smaller case applied to include the arm and forearm. This remains on for three months and thereafter a sling is worn and daily physiotherapeutic treatment employed.

The Spine

Spinal fusion is commonly carried out in tuberculous disease and in America is also widely practised in the immediate treatment of crush fractures of the vertebrae. Lumbo sacral and sacro iliac arthrodeses are also becoming increasingly popular as remedies for low back affections. For sacro iliac arthrodesis the most satisfactory technique would appear to be that of Smith Petersen while for the other segments of the spine the operation of Albee is to be specially commended. The technique of these operations is described in their appropriate place.

Other Joints

Methods of operative fixation are not necessarily restricted to the larger joints. Indeed the efficient fixation of certain of the small joints may be a matter of supreme importance in preserving the function of the hand or foot. Naughton Dunn's tarsal arthrodesis for example is one of the most notable contributions to the surgery of poliomyelitis.

The Wrist

Arthrodesis of the wrist is indicated when the joint is flail when it is ankylosed in faulty position and in painful arthritis a sequel of such conditions as an united fracture of the scaphoid, Kienbock's disease and also following tuberculous or infective lesions.

In a paralytic flail wrist with good finger function tendon transplantation is a preferable procedure and arthrodesis should be undertaken only when transplantation fails.

The grasping power of the fingers is considerably greater when the wrist is in a position of dorsiflexion so that in spastic drop wrist the function of the fingers is improved by ankylosis of the wrist in dorsiflexion. Probably the best operation is Brittain's modification of the Albee operation in which the joint is arthrodesed in dorsiflexion. This operation does not interfere with the power of pronation and supination.

The Brittain Operation A straight incision is made on the dorsal aspect of the wrist extending from 4 inches above the joint to 1 inch from the proximal end of the third metacarpal. The bones are exposed

and a gutter made for a graft. This is about half an inch broad and is cut from 2 inches in the radius and extends into the proximal half of the third metacarpal. It is conveniently cut with a very sharp osteotome which is also used to excavate into the marrow cavity of both bones under the cut ends of the bed. The graft is cut with a step at each end so as to

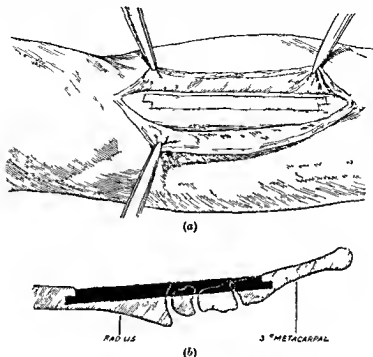


FIG. 394.—Brittain's Arthrodesis of the wrist.

(a) The method of cutting the graft.

(b) The slotting of the graft into the wrist bed.

fit into the medullary cavity of both radius and metacarpal, a little traction being put on the fingers to allow the graft to be levered and fitted into its bed. When the traction is released the metacarpal overlaps the graft and holds it securely, the step in the graft fitting snugly into the two medullary cavities and locking the joint. The arm is immobilized for four months.

ARTHROPLASTY

Arthroplasty, which has come to occupy an increasingly important place in the work of the orthopaedic surgeon, may be defined as a reconstructive procedure which seeks to restore mobility to an ankylosed joint. Although joint mobility may occasionally follow as a result of osteotomy, the mere division of bone can scarcely be considered a true arthroplasty since the restoration of movement is not the main objective. There is often confusion, too, between excision and arthroplasty, especially in the elbow joint. Excision is merely the removal

of sufficient bone to induce a pseudo arthrosis, whereas arthroplasty is the reconstruction of the component parts necessary to function. It should be borne in mind that in reconstructing joints stability is of equal importance to free movement, and, if arthroplasty is to occupy an important place in operative orthopaedics both these requirements must be fulfilled.

The first attempts at mobilizing joints consisted in performing a simple osteotomy and preventing subsequent union by traction. In this way a patient sometimes obtained a stable, weight bearing and movable joint, but the result was always uncertain. In the modern form of arthroplasty, joint surfaces are formed, and a piece of soft tissue interposed between them, in the expectation that its presence will interfere with the subsequent fusion of the surfaces and result in the formation of a permanent joint. The method has been attended by a large degree of success, and is now generally accepted as the standard form of operation. The justification for the procedure is based on the subsequent changes which the interposed flap undergoes. The portion between the bone ends becomes liquefied, and a sac or cavity, lined with adventitious tissue, forms which is not unlike that of a physiological joint or bursa.

Various materials may be employed as flaps, including pedicled muscle flaps, pieces of pig's bladder, fascia impregnated with chromicized silver, free fascia lata, and pieces of the anterior abdominal wall of rabbits. The interposed tissue is laid over the new joint surfaces and serves in some measure to prevent any gross inflammatory reaction in the joint—an important point since the formation of granulation tissue would almost certainly lead to fresh ankylosis. Certain additional steps are necessary, however to prevent further the formation of this granulation tissue, since even the most minor surgical procedures are followed by some degree of inflammatory reaction. The most important points in the technique of arthroplasty in this connection are strict asepsis and careful hæmostasis. After operation complete immobilization of the joint should be insisted upon until the tissue reaction has settled down.

Indications for Arthroplasty Arthroplasty may be employed for ankylosis resulting from a variety of conditions but careful consideration must be given to each individual case before it is decided upon. The operation is indicated only when the mobilization of a stiff joint will materially improve the function of a limb, and arthroplasty is likely to fall into disfavour, both amongst orthopaedic surgeons and amongst patients if the latter requirement is not fulfilled.

Certain other factors must be taken into account, however, as Hey Groves has pointed out. These are

- 1 The nature of the causative disease
- 2 The nature and extent of the disability
- 3 The circumstances of the patient

1 **The Importance of the Nature of the Causative Disease**
 Arthroplasty should be undertaken only in joints which are biologically sound i.e. joints which contain no traces of either active or latent inflammation. The operation therefore has theoretically no place in the treatment of tuberculous joints as these can rarely be considered soundly healed and free from risk of recurrence. In an exceptional case in which the disease has been almost confined to the synovial membrane and in which the bony constituents of the joint are sound and healthy a good result may sometimes be obtained. In bilateral disease of both hips or knees arthroplasty should be considered if the disease is healed. It is conceivable that it might be considered in old tuberculous joints cured by arthrodesis.

When joint ankylosis has followed a gonococcal or a pyogenic infection a considerable time must elapse before the operation is undertaken in order that there may be a reasonable assurance that all inflammation has subsided. One to two years is usually considered a safe limit in the case of ankylosis from pyogenic infection.

The results of arthroplasty in rheumatoid arthritis are on the whole poorer than in the other types of ankylosis because there is an ever present danger of recrudescence and it is extremely difficult to control the tissue reaction of such a joint.

Where a joint has become ankylosed following the reception of some severe trauma arthroplasty is the procedure of choice and similarly where a joint has become obliterated by a bony ankylosis as the end result of a violent inflammatory reaction the operation may be undertaken with complete confidence.

The result of the operation is to some extent influenced by the condition of the chief muscles controlling the joint. If the flexor and extensor muscles are well developed and free from toxic atrophy or scarring then there is an excellent prospect of a movable joint resulting. In the knee for example the condition of the quadriceps is all important and arthroplasty should never be undertaken when this muscle is grossly atrophied or where extensive adhesions exist between the muscle and the front of the femur.

In addition to the state of the musculature the condition of the remaining soft parts must also be considered particularly when the ankylosis has followed severe war injuries. If there has been extensive destruction of skin or gross interference with the vessels or nerves in the region of the joint the technical difficulties of the operation may be so great as to render it inadvisable unless preceded by some such preliminary operation as a pedicle flap graft or tendon lengthening or stretching.

When the joint has become fixed in bad position the deformity should be corrected at a previous operation. In such cases it might be possible to correct the alignment while the arthroplasty was being performed but in the majority of cases the deformed attitude would make the operation technically too difficult. This is particularly the

case in the hip joint where ankylosis in flexion and adduction must be corrected by preliminary osteotomy. The presence of osteoporosis or bone atrophy is unfavourable since they interfere with the remodeling of the bone for the new articulation. Alteration of the internal architecture such as the presence of a medullary cavity through the area of the new joint does not favour the formation of a new joint.

Arthroplasty may be said to enter its sphere of greatest usefulness in those cases in which more than one joint is ankylosed. According to McAusland where both hip joints are fixed arthroplasty should be carried out certainly on one side and possibly on both. Where both elbows are ankylosed the operation again should be performed on each side and when the knees are fixed arthroplasty should be performed on one side. When both hips and knees are affected—a condition not infrequently seen in multiple arthritis—an attempt should also be made to mobilize one or more joints.

2 The Nature of the Functional Impairment Ankylosis in good position is quite compatible with efficient function of the limb and unless a movable joint is going to confer some extra advantage to the patient arthroplasty should be avoided. Where the position of the ankylosis is bad or where the ankylosed joint is painful or becoming progressively deformed then the operation is definitely indicated if the other circumstances of the case are appropriate but it must not be rashly undertaken. In each case the surgeon must decide whether the patient's requirements will not be served best by excising the offending joint and arthrodesing it in a proper position. In this connection a sharp distinction must be drawn between the upper and the lower limb. In the arm mobility is all important whereas in the leg strength and stability are essentials which must not be sacrificed for the sake of movement.

3 The Patient's Circumstances Due consideration must be paid to the temperament and social position of each individual patient while the age is also of importance. The success of the operation depends upon complete and willing co-operation between the patient and the surgeon and the individual must be willing to suffer a considerable amount of pain during the early days of convalescence and to submit himself to punishment after treatment. It is futile therefore to attempt an arthroplasty unless the patient possesses the time and the means to undergo this necessary after-care. Arthroplasty is attended with most success when undertaken in young people provided the period of active bone growth has passed. The age period during which it may be confidently and appropriately performed is usually placed between the time active growth stops and the age of 40. The prognosis is not favourable in children as the epiphysis may be traumatized at operation and growth arrested or distorted.

Technical Considerations in Performing any Arthroplasty

Hey Groves has pointed out that in the making of a new joint there are certain essential and constant procedures to be performed. These are

(i) *The Formation of the Gap* Hey Groves stresses the fact that sufficient bone must be removed to permit free movement in the desired direction. At the same time care must be taken not to excise too much, lest a flail joint result.

(ii) *The Shaping of the Bone ends* The bone ends are usually roughly shaped by a saw, and then smoothed out by filing. The new joint is constructed either on the principle of a hinge or of a ball-and-socket joint. In making a hinged joint, the articular surface must be made as wide as possible, and the two joint surfaces should be made respectively convex and concave, in order to increase the stability.

(iii) *The Covering of the Bone ends* Many methods have, from time to time, been resorted to in order to ensure a covering over the bone ends. In the original types of the operation, the bones were allowed to become coated with granulation tissue. Hard wax has also been employed and, in a sense, it has been satisfactory, for it checks the bleeding and to some extent controls the exuberance of the granulation tissue and ultimately, therefore, of the fibrous tissue.

In modern arthroplasties, the preference is for pedicled flaps, as these form a satisfactory covering and at the same time retain their blood supply and vitality. When for any reason they cannot be obtained, then a free graft of fascia lata should be employed. This also retains its vitality, and is associated with little or no tissue reaction. The bone ends are each generously covered by a flap, which is then firmly secured in position.

(iv) *The Prevention of Adhesions, and the Production of a Synovial Cavity* These objects are best fulfilled when the wound heals smoothly and rapidly, and when the limb has been subject to sufficient traction to keep the bone ends some distance apart. At the time of operation, it is essential to secure complete hæmostasis, otherwise blood clot forms between the bone ends and later organizes into fibrous tissue, as a consequence of which the new joint rapidly becomes the site of a fibrous ankylosis. The after care is also important in this connection. Active movement should be begun early.

(v) *The Provision of New Ligaments, and the Prevention of Undue Mobility* This factor becomes important only in the reconstruction of joints whose stability depends mainly on the peri-articular ligaments. In the case of the hip joint, for example, where there is little or no lateral strain, the soft parts round the joint are generally sufficiently strong to compensate for the loss of ligamentous control. In the knee joint, on the other hand, stability is essential, and must be obtained at all costs. To this end, Albee cuts the bones in a V shaped manner, so that they fit accurately into each other and prevent lateral

mobility. Hey Groves suggests, somewhat extravagantly, that if stability has been seriously compromised, the main ligaments can be reconstructed adequately by a further operation at a later stage.

(vi) *The Restoration of Function.* To obtain the fullest possible return of function, careful and prolonged after-treatment is essential. Traction is applied and the joint surfaces kept apart until a new synovial cavity has formed. In addition, the application of traction ensures that the part is kept at rest. In eight to ten days, when healing is presumed to have occurred, graduated movements should be begun, but weight-bearing should not be permitted for a considerable time.

Arthroplasty of Individual Joints

For all practical orthopædic purposes only four joints lend themselves satisfactorily to arthroplasty. The temporo-mandibular joint is rarely the site of ankylosis, and in any case is outwith the province of the orthopædic surgeon. In the shoulder, arthrodesis in good position gives such good results, especially when the muscles which rotate the scapula are strong, that it is usually preferred to arthroplasty. In hand and foot conditions, arthroplasty is not associated with much improvement, save in hallux valgus and hallux rigidus, where mobilization of the metatarso-phalangeal joint effectively relieves the pain. Attempts at reconstruction of ankylosed fingers have hitherto been unsuccessful, but better results may accrue from the method recently described in which the whole phalanx is excised instead of merely a small part. In any case, the extensor tendons are so intimately related to the joint capsule that when a small part of the head or the base is removed adhesions ultimately occur between the tendons and the reconstituted joint, and fresh ankylosis occurs comparatively soon.

1. Arthroplasty of the Elbow Joint.

Ankylosis of the elbow joint is common, but fortunately the joint is not a weight-bearing one and arthroplasty is usually successful. The following are the indications:

1. Ankylosis following trauma.
2. Tuberculosis. Tuberculous disease of the elbow is usually mild, and readily heals under conservative treatment, though the joint is often left stiff and ankylosed. The bone-ends, however, are so often healthy that arthroplasty can be carried out with a good prospect of success.

Arthroplasty of the elbow is contra-indicated in men of the labouring classes, if the ankylosis is in good position, and if they are able to carry on their work. In such cases, a fixed joint is stronger, and therefore more useful for hard manual work, than a joint whose stability has been reduced by mobilization.

The Method. Arthroplasty of the elbow in its simplest form consists of a simple excision of the joint; usually a flap of soft tissue is interposed in addition. Successful mobilization after simple excision

depends upon the amount of bone removed, and since there is only a narrow margin between a movable, stable joint and a flail joint the operation must always give rise to considerable anxiety. It is usually impossible to secure an adequate pedicled flap from the neighbourhood of the elbow, and a flap of fascia lata is the more usual covering selected for the bone ends.

The Operation A straight posterior vertical incision is made through the skin and the flaps reflected. The triceps and periosteum are detached from the olecranon, and the soft parts freed from the medial condyle of the humerus care being taken to preserve the ulnar nerve. The line of the bone division is through the lower end of the humerus and the bone ends must be accurately adapted. The lower end of the humerus is modelled into a V shaped projection and the articular surface is left as wide as possible. The olecranon is preserved, and the ulna cut only in such a way as to exaggerate the depth of the sigmoid notch. The head of the radius is completely removed along with the scar tissue lying round the joint. A flap of fascia lata is now removed from the lateral surface of one thigh and suitable portions of it wrapped round the three bone ends so as to cover the raw surfaces completely. To secure accurate attachment between the fascia and the bone the flap should be sewn down by kangaroo tendon passed through drill holes or fixed with a purse string suture. The triceps tendon is then sutured to the olecranon and the skin incision closed. The arm is slung to an overhead beam with the elbow flexed to a right angle. By this method the weight of the arm is taken on the hand and this usually supplies a sufficient degree of traction.

Albee has suggested a modification of the usual technique in which by an elongation of the olecranon process greater leverage will be given to the triceps and indirectly greater stability to the joint. An incision 4 to 6 inches long is made from just proximal to the olecranon up down the crest of the ulna (Fig 39c). The olecranon and about $3\frac{1}{2}$ inches of the posterior surface of the ulna are cut away by two cuts which converge both longitudinally and laterally. This piece of ulna is turned up with its attachment to the triceps tendon and the joint is exposed. Its surfaces are cut away and smoothed and then covered by a piece of fat covered fascia taken from the thigh. The separated piece of ulna is then fixed in position at a higher level than it originally occupied so as to afford it greater leverage action. The arm with the elbow flexed is put in a plaster case up to the axilla for six weeks after which massage and manipulations are begun.

2 Carpo metacarpal Arthroplasty.

Ankylosis of the thumb in a bad position is particularly disabling. It may result from a comminuted Bennett's fracture. Successful cases have been reported by the following method.

A straight incision is made from the dorsal surface of the interphalangeal joint of the thumb proximally and passing over the anatomical snuff box between the extensor tendons. The area of the

carpo-metacarpal joint is exposed and the old joint line cut into and through with an osteotome. The base of the metacarpal is freed and may be brought out of the wound to be prepared and filed smooth after sufficient of the bone has been removed to permit free motion. A strip of fascia lata is wrapped round the head and held in place with a purse-string suture. After suture of the wound a plaster case is applied with the thumb abducted and opposed. Active motion is begun in fourteen days.

3. Arthroplasty of the Hip Joint.

This is one of the most important weight-bearing joints in the body and the question of arthroplasty, therefore, constitutes a difficult problem.

The Indications for the Operation. The principal indication for arthroplasty of the hip is in the case of bilateral ankylosis, when other

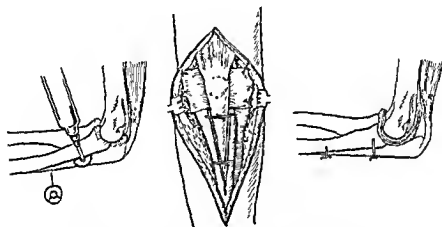


FIG. 393.—Albee's operation for Arthroplasty of the Elbow.

factors favour mobilization. Unilateral ankylosis in bad position is also an indication, provided the subject is a good operative risk. When the general condition is poor osteotomy is preferable to arthroplasty. Baer believes the procedure to be a proper one in ankylosis following gonococcal arthritis or following trauma. He is more guarded when the primary condition has been a pyogenic or tuberculous arthritis, and he believes the operation should never be performed in cases of osteo-arthritis.

According to Hey Groves, arthroplasty of the hip is indicated in three conditions:

1. Simple bony ankylosis following old infection.
2. Massive ankylosis following trauma, with superadded infection.
3. Painful osteo-arthritis (see p. 418).

His operative technique varies with the type of case. He employs Jones's pseudarthrosis in the simple ankylosis following old infection.

He divides the femur below the trochanter, making the bone ends saddle shaped. He then turns in a flap of fascia lata. In this way he avoids entering the joint and therefore runs no risk of reawakening latent sepsis or of inducing fat embolism. For osteo arthritis Hey Groves advocates a simple excision in which the diseased bone is removed from the head and the neck stump rounded off and filed down until its extremity assumes a globular shape. A flap of soft tissue is then turned in to cover it.

The more formal method of performing arthroplasty is as follows.

The joint is approached through a Smith Petersen incision. The attachments of the capsule to the neck of the femur should not be stripped since they carry the important circulation of the epiphyseal and periosteal vessels. It has been found that wide exposure with removal of soft tissues and consequent damage to the circulation may cause necrosis of the head with later dissolution. The head is detached from the acetabular surface of the ilium by means of a broad gouge the line of separation following the old joint line. When this line of demarcation is not clearly demonstrable the gouge is entered at the point where one supposes the old articulation to have been. The head is then completely extruded from the socket roughly rounded off and finally filed down to make it as smooth as possible. The acetabulum is then excavated until it is large enough to receive the new head but great care should be taken to preserve the acetabular roof. It is important to remove as small an amount of bone as possible in order that the component parts of the joint may be preserved at or fairly near their normal size. The bone ends having been thus prepared any neighbouring fibrous tissue should be excised.

The bone ends are next covered over. Any of the materials in common use may be employed for this purpose. Baer uses the submucosa of the pig's bladder which is previously chromicized so that it remains *in situ* for a matter of fifty days. Other workers have relied on the abdominal wall of the rabbit or other animal tissue while others and the author is one are still content to use autogenous grafts of fascia lata. Whichever tissue is selected the flap should in each case be carefully sutured with chromicized catgut to the fibrous periosteum of the femoral neck. While not absolutely essential better results are sometimes obtained if the floor of the acetabulum is also covered over by a flap. The head is then replaced in the acetabulum and the wound closed without drainage. The leg is immobilized in a plaster spica for two or three weeks after which the plaster is bivalved and the patient encouraged to carry on active movements. Later massage and radiant heat should be administered. Walking with a traction splint and crutches is allowed in two months and after another month's interval weight-bearing is carefully and gradually begun.

Smith Petersen's Cap Arthroplasty (p. 418) is now being used more frequently than the above method. Results of both types however are often disappointing.

4 Arthroplasty of the Knee

Owing to the structural complexity of the knee joint arthroplasty in this situation is a difficult and intricate problem. The stability of the normal joint depends on its ligamentous support both inside and outside the joint cavity. Arthroplasty of the knee therefore has previously been regarded with scorn and with scepticism. This point of view has in modern days gradually changed owing principally to the excellent work of Putti in Italy and of Albee in America both of whom have obtained satisfactory results in a long series of cases.

The most favourable age to undertake the operation is from adolescence to 10 years. It is contra indicated in children in whom the epiphysis is liable to be traumatized and in whom it is usually impossible to secure proper co-operation in the after treatment. It should also be avoided in the presence of much scar tissue or when the skin is adherent to the bone. When the limb is shortened by more than 3 inches the operation should be avoided since it causes further shortening. The results are also uncertain in large obese individuals.

Arthroplasty should be carefully considered in ankylosis following pyogenic arthritis and following trauma. It is of value in gonococcal ankylosis and osteo arthritic and rheumatoid arthritic fixation.

Regarding its use in tuberculosis there is a difference of opinion. Putti and Henderson consider that the operation is definitely contra indicated in tuberculosis. The present writer believes that it may be permissible in specially selected cases where the active disease has been healed for a long period. Arthroplasty can also be undertaken when the tuberculous disease has been cured by a previously performed arthrodesis if the bone shows sufficient recalcification on radiological examination. In the above circumstances it should be carried out only at the patient's express desire.

It may also be employed when there is deformity which requires correction. The latter observation of course refers only to minor degrees of deformity and it should be understood that extreme distortion of a joint is a definite contra indication to arthroplasty.

The Technique of Arthroplasty of the Knee The operation should never be undertaken without the preliminary application of a tourniquet which is applied as high up the thigh as possible so that it does not interfere with the application of a plaster. The joint is often approached through a Putti's incision—the so-called goblet incision. The stem of the incision runs along the quadriceps tendon to the upper border of the patella and from that point the diverging limbs of an inverted U encircle the knee cap. Most surgeons however follow Albee and make a U shaped incision round the patella with its concavity upwards. In either event the ligamentum patellæ is detached from the tibia along with a generous portion of the tuberosity. The soft tissue and the remains of the capsule are now dissected off from the ankylosed joint and along with the patella and the patellar

tendon, are turned upwards to expose completely the anterior and lateral surfaces of the ankylosis

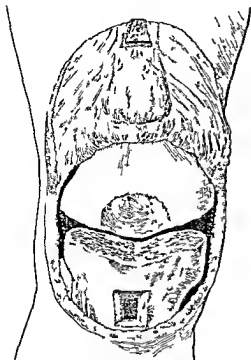


FIG 396—Arthroplasty of the knee

Albee's method of setting the bones to aid stability

Campbell tries to conserve a portion of the posterior cruciate ligament to maintain the circulation to the medial condyle. He states that great care should also be taken not to interfere with the circulation to the lateral condyle by stripping the periosteum and soft parts from the bone posteriorly and severing the lateral ligamentous attachment.

The bone is then divided in a V shaped fashion, with the apex of the V pointing downwards, and the angle between its limbs equal to 120 degrees (Fig 396). The femur is thus left with a projecting apex. The posterior edge should be rounded off to ensure good flexion. The upper surface of the tibia is so shaped that it presents a corresponding V shaped depression to accommodate the lower end of the femur. Adaptation of the joint

surfaces in this way minimizes to a remarkable extent any lateral instability since the wedge at the lower end of the femur is forced into the corresponding tibial notch each time weight is borne on the limb.

After their preliminary preparation the raw bone surfaces are smoothed and filed down in order to facilitate motion. A rectangular flap of fat and fascia lata should then be cut from the lateral aspect of the thigh. This graft is laid over the raw bone surfaces, and sutured in position with chromicized catgut. If the patella has been ankylosed to the front of the femur, it may be necessary to interpose a second flap of fascia in this situation.

At the completion of the operation adhesive strapping is applied on either side of the leg, and, before the tourniquet is removed, a plaster of Paris case is fitted. The plaster bandages should be applied from below upwards and should be fairly tight. If these requirements are fulfilled, the plaster exerts both a compressing and immobilizing effect and, therefore, has a marked hæmostatic influence.

A weight of 15 lb is now fixed by means of tape to the adhesive strapping bands along the medial and lateral sides of the limb. This traction is usually continued for about four weeks, after which the plaster

is removed and massage commenced. The case, however, may be hvalved at the end of two to three weeks and the patient encouraged to begin active movement then. Weight bearing, on crutches, may be allowed three months after the operation, and thereafter a knee cage should be fitted, with the lateral irons extended down and fitted to a box in the heel of the shoe. This obviates downward slipping of the cage.

If there is still lateral mobility at the knee after three or six months, Hey Groves recommends a second operation, designed to reinforce the lateral ligaments. Secondary operations may also be required in order to divide contracting bands of fascia or scar tissue which are apt to form beside or above the patella, and give rise to limitation of movement.

CHAPTER XX

AFFECTIONS OF SOFT TISSUES

GANGLION

A ganglion is a cystic swelling in the neighbourhood of a joint or tendon sheath particularly at the wrist at the foot or at the knee. The cyst is unilocular or multilocular and contains a clear jelly like colloid material or a thick mucinous fluid.

PATHOLOGY

There is usually one large main cyst either unilocular or multilocular, to which a series of accessory cysts of varying size are attached. The wall of the cysts consists of dense fibrous tissue resembling that of the capsule of a joint. The lining layer is a smooth shining white membrane arising as a condensation of the fibrous tissue of the wall. The cysts are filled with a thick sticky colourless fluid of the consistency of soft jelly and probably of the nature of mucin. They have usually no direct communication with the joint or the tendon sheaths.

The microscopic findings show that the development of ganglia may be divided into three fairly definite stages. The first stage is characterized by a large number of spheroidal cells which are closely packed together and merged by insensible gradations into spindle cells of the periphery. The second stage may possess features of the first stage and present a central area which is beginning to take on the characteristics of a cavity filled partly with a secretion from those cells. Sometimes all of the spheroidal cells undergo the mucoid change at the same time so that the mucoid material abuts on the spindle cell tissue. It is in the third stage that one finds the changes seen in the well developed ganglion. In this stage the wall is smooth and of variable thickness and the lining membrane bears an astonishing resemblance to the synovial membrane of joints. The walls of the larger cysts are poorly supplied with blood vessels and in many cases the vessels show a marked fibrosis of their wall and narrowing of their lumen. Indeed, it has been suggested that the vascular lesion is the real cause of the degeneration the impoverished blood supply being supposed to induce a local impairment of nutrition.

Bundles of nerve fibres are frequently observed passing through the degenerated areas. These may account for the pain and tenderness which are so often associated with ganglion formation.

ETIOLOGY

The observations of Carp and Stout suggest that a mucinous degeneration occurs in the dense connective tissue adjacent to joints and tendon sheaths. This affects the collagen in a number of isolated but closely approximated areas and a series of small cysts arise which later coalesce to form the larger cysts containing mucin.

The occasional occurrence of mitosis and the great thickness of the walls of most of these ganglia indicate that a tissue reaction must have been called forth by the degeneration. That this cellular proliferation is directly due to the accumulation of the mucinous fluid is borne out by the frequency with which the entire process is arrested by the dispersal and absorption or the withdrawal by aspiration of the fluid. King believes that the process may be regarded as a proliferation of cellular structure, a disintegration of cells and an accumulation of cellular secretion with the formation of a cavity. He concludes that the process is not primarily a degeneration of cellular tissue but a secretion of the synovial cells. He believes that the chief causes are trauma and a constitutional factor.

CLINICAL FEATURES

A ganglion gives rise to swelling, impairment of function and pain. The swelling may be gradual or sudden in its onset and once established is often found to vary from time to time. The size varies with the situation, the largest occurring on the dorsal aspect of the wrist and in the popliteal region. It may be visibly multilocular but more frequently it is smooth and rounded. It can be rendered more apparent by stretching any tendons to which it is attached. The ganglion is usually tense but a few are fluctuant.

Pain when present radiates from the site of the swelling and is pronounced when the neighbouring joint is moved. If the ganglion is connected with a tendon sheath a feeling of weakness may be experienced in the digits in which the tendons are inserted.

They are met with during the second, third and fourth decades, usually in women; thereafter they become progressively more rare and are uncommon in old age.

Ganglia are to be recognized from their situation and their physical characters. They must be distinguished from tuberculosis of the related joint or tendon sheath from lipoma, myxoma, sarcoma, fibroma, bursitis and osteoma.

Sites

(1) *The Wrist*—On the dorsal surface of the wrist ganglia may occur on the radial, ulnar or medial aspect. They are usually found over the articulations between the navicular and the lunate and between the multangulum minor and the capitate. They are situated in the interval between the extensor pollicis longus laterally and the extensor digitorum communis and extensor indicis on the medial side. On the volar aspect

of the wrist they usually lie between the tendons of flexor carpi radialis and brachio radialis in close relation to the radial artery. They are often intimately attached to the flexor tendon and in some instances may be adherent to the skin.

(ii) *Tarsal Ganglia* In the foot ganglia are situated on the dorsum in relation to one or other of the intertarsal joints. They are usually smaller and flatter than the wrist ganglia and are often mistaken for a solid or even a bony tumour.

(iii) *Ganglia in the Region of the Knee* At the knee ganglia occur in the interval between the femur and the leg bones, usually on the lateral aspect of the joint in front of the tendon of the biceps. They

are distinct from semilunar cysts but since the two conditions are analogous the differential diagnosis is of little moment. They may arise also on one or other side of the patellar ligament in this situation they may grow to a considerable size and project beyond the ligament on each side. Ganglia in connection with the knee joint may give rise to discomfort and stiffness and so interfere with the use of the limb to a large extent.



FIG. 397.—Ganglion of the knee joint

TREATMENT

Many authorities recommend a preliminary trial of non-operative treatment before radical surgical interference is undertaken.

The simplest mode of treatment is the aseptic modification of the old-fashioned Seton method. The overlying skin is carefully sterilized and a needle carrying a double thread of thick silkworm gut is passed through the cyst. The suture is left protruding from both needle punctures its ends cut short, and a dressing applied. A week later the silkworm gut is removed and the punctures sealed with collodion. An aseptic reaction is thus induced and the cyst is obliterated by granulation tissue.

The ganglion may be ruptured by gradual pressure by the finger or by a sudden blow. Those attached to the capsule of a joint have a thicker connective tissue wall however and are in addition better protected by soft parts so that they are difficult to burst.

The contents may be aspirated and an irritant, such as tincture

of iodine or carbolic acid injected Afterwards a firm bandage should be applied

Gunther has suggested and practised successfully the injection under local anaesthesia of collodion into the ganglion after the contents have been aspirated A tight bandage is afterwards applied In twenty four hours there are signs of slight inflammation with some redness and swelling In three days the ganglion has disappeared In the hands of Gunther the treatment has always been successful and he has had no case of recurrence

When non operative means have been unsuccessful surgical treatment should be instituted The whole of the cyst wall must be removed otherwise recurrence takes place In extremely careful technique is therefore essential general anaesthesia strict asepsis and the control of hæmorrhage by a tourniquet The ganglia arising from the capsule of joints are intimately adherent to them and usually have a broad base so that they can be excised only by sharp dissection If in the process the joint is entered the capsule need not be closed but it is important to secure complete hæmostasis and a firm bandage applied after the operation tends to minimize the risk of a hæmatoma

AFFECTIONS OF BURSAE

A bursa is a closed sac lined by endothelium and containing synovial fluid It is usually situated over a bony prominence in the vicinity of a joint or at a point where a tendon or a muscle moves over a projecting portion of bone Bursæ may or may not communicate with the joint cavity their function is to lubricate and protect the more delicate structures from pressure Some such as the pre patellar and olecranon bursæ are constantly present while others such as the bursæ which develop over exostoses and over a kyphus in a tuberculous spine are adventitious and develop as a result of continual irritation Amongst the adventitious bursæ are the following

(1) *Tailor's ankle* over the subcutaneous area above the lateral malleolus a large bursa often appears in tailors who sit in the cross legged position thus bringing this area in contact with the table

(2) *Porter's shoulder* between the upper surface of the clavicle and the skin in those who carry loads on the shoulder

(3) *Heaver's bottom* between the gluteus maximus and the ischial tuberosity

(4) *Bunions* from pressure of faulty shoes over the medial part of the head of the first metatarsal bone

(5) *Calcanean* between the insertion of the tendo calcaneus and the overlying skin

(6) *Kyphotic* over the prominent part of the vertebral spinous processes and the skin in some cases of kyphotic curvature of the spine

Since bursæ are similar in most respects to the synovial membrane of the joints, they are subject to similar types of disease which may be classified as follows

- 1 Traumatic
- 2 Infectious
- 3 Syphilitic
- 4 Gouty

1 Traumatic Bursitis

A blow over a bursa is followed by an effusion, usually serous, which appears rapidly and subsides gradually. Repeated injuries of a minor nature, such as those that occur in certain occupations, may also produce acute bursitis. This traumatic or occupational, bursitis, is by far the most common lesion of the bursæ. The wall becomes so thick, and the lining cells so degenerate, that the secreting fluid is no longer absorbed and the sac becomes greatly distended, as for example in "housemaid's knee". It is usually thought that there is some toxic factor at work in addition to the trauma since only a small proportion of those who require to kneel for long periods ever suffer from pre patellar bursitis.

SYMPTOMS

If the inflammation is acute, the part is hot, swollen, and tender, fluctuation can usually be elicited and the patient is unable to use the limb.

The majority of cases are chronic in type, and there is a gradual accumulation of fluid within the sac, constituting the bursal hygroma. In time the wall of the bursa becomes enormously thickened and fibrosed, and there may even be septa running across the cavity. When the thickening is extreme a fibrous tumour may be formed, which is distinguishable from a neoplasm only by reason of a small cavity which persists in the centre of the 'tumour'. Loose bodies are often present, and may be recognized on palpation.

TREATMENT

In acute cases the condition may subside with rest and hot fomentations but when the bursal wall is thickened, the complete sac should be excised.

2 Infectious Bursitis

Infection of a bursa may be due to the introduction of virulent pyogenic bacteria or to a more attenuated low grade type of organism. The acute form may be suppurative or non suppurative, depending upon the type and virulence of the organism. The source of the infection is probably one of the common distant foci of infection such as the tonsils the air sinuses, or the teeth. Chronic gonococcal infection is also a common cause, while typical tuberculous bursitis, with caseation and sinus formation, is occasionally seen. The tuberculous type occurs chiefly in the pre patellar and sub-deltoid bursa, or in one of the bursæ over the great trochanter.

TREATMENT

An acute infectious bursitis is treated on similar lines to other inflammatory processes. The chronic form which is usually tuberculous should be excised.

3 Syphilitic Bursitis

The pre patellar, the sub acromial and the olecranon bursæ may be implicated during the tertiary stage of syphilis.

Syphilitic bursitis is characterized by a primary effusion into the bursa, which later breaks down to form sinuses or ulcers. In all forms of chronic bursitis the blood should be examined and when the Wassermann test is positive anti luetic treatment employed before surgical methods are advised.

4 Gouty Bursitis

In association with gout degenerative changes sometimes occur in the bursæ usually the olecranon and the pre patellar. The bursal wall is the site of a chronic inflammatory change and the lumen is distended by chalky deposits.

DISEASES OF INDIVIDUAL BURSÆ

Bursitis of the Foot and Ankle

Adventitious bursæ may develop over any of the bony prominences of the foot and ankle under the stimulus of constant irritation. Thus an industrial or trade bursa popularly known as the 'tailor's ankle' may form over the lateral malleolus.

A retro calcanean bursa is commonly present between the tendo calcaneus and the tuberosity of the calcaneus and when distended forms a painful fluctuating swelling over the back of the heel. Similarly there may be a bursa between the insertion of the tendo calcaneus and the overlying skin and infection of this bursa is known as calcanean bursitis. The symptoms of bursitis in the region of the heel are pain and tenderness on pressure which are aggravated by standing and walking. It is usually sufficient in the milder cases to remove the counter (stiffening) from the shoe when walking. In obstinate cases the bursa may require to be excised and any exostosis shaved off. (See also p. 774.)

A bursa is also met with occasionally on the under aspect of the calcaneus often associated with a spur—the sub-calcanean bursa. When inflamed there is pain and tenderness on the under aspect of the heel. In excising the sub calcanean bursa a flap is turned down wards and forwards from the heel the bursa dissected out and the spur, if present removed. The bursa most frequently seen in the foot is that which develops over the exostosis of a hallux valgus.

Bursitis of the Knee

Numerous bursæ occur in the vicinity of the knee joint, in relation to the attachments of the various muscles and ligaments. *Anteriorly* there are four bursæ, these are the supra patellar and the pre patellar bursæ a small subcutaneous bursa sometimes present in front of the tibial tuberosity, and the infra patellar bursa between the proximal extremity of the tibia and the deep surface of the ligamentum patellæ.

Posteriorly there are two bursæ, one between each head of origin of the gastrocnemius and the capsule of the joint. They often communicate with the joint. The bursa between the medial head of the gastrocnemius and the capsule sends a prolongation between the gas-

trocnemius and the semimembranosus. This bursa is often enlarged, forming a swelling at the inner side of the popliteal space which is spoken of as enlargement of the semimembranosus bursa.

On the *medial* side there are three bursæ. One separates the tendons of the sartorius, gracilis, and semitendinosus from the tibial collateral ligament as they cross it. The other two separate the tendon of the semimembranosus from the tibial collateral ligament medially and the head of the tibia laterally, and serve to protect the tendon which is sandwiched between the ligament medially and the condyle of the tibia laterally.

On the *lateral* aspect of the knee joint there are three bursæ—one between the biceps tendon and the fibular collateral ligament, one between the fibular collateral ligament and the pop-

liteus tendon and a third between the popliteus tendon and the lateral condyle of the femur. This last bursa is really a tube of synovial membrane round the popliteus tendon, like that around the long head of the biceps at the shoulder joint, and therefore communicates with the joint.

Symptoms arise most frequently in relation to the pre patellar and the infra patellar sacs, in the bursa deep to the medial head of the gastrocnemius and in those deep to the tendon of the semimembranosus.

1 Pre-patellar Bursitis The pre-patellar bursa is subcutaneous, and is present in about 90 per cent. of people. It usually covers the lower half of the patella and the upper half of the patellar ligament. It is most commonly affected in women of the servant class, or in those



FIG. 398.—Pre patellar Bursitis

whose occupation demands prolonged kneeling. Indeed, effusions into the bursal sac are popularly known as "housemaid's knee" because in scrubbing the hands rest on the floor bringing the bursa into contact with the ground. Priests do not get pre patellar bursitis because when they kneel in the upright position the bursa is not brought into contact with the ground.

In addition to traumatic effusions, it is perhaps the most usual site for the syphilitic form of bursitis.

Pre patellar bursitis has to be carefully distinguished from osteomyelitis and tuberculosis of the patella, occasionally in the suppurative type, where there is also necrosis of the superficial aspect of the patella, it may be difficult to determine whether the bone or the bursal infection was the original lesion. The knee joint is practically never involved, owing to the dense ligamentous and fibrous structures which are interposed between it and the bursa.

TREATMENT

The treatment of acute bursitis is that of any ordinary infection—rest and hot fomentations. The fluid may in addition be aspirated repeatedly, but the relief so obtained is not permanent. If the effusion suppurates the bursa should be drained by two lateral incisions.

In chronic infections complete excision of the sac is the most successful method of treatment. The dissection is performed through a longitudinal incision to either side of the middle line and the knee should be immobilized for ten days following the operation until the wound has healed, thereafter active function may be resumed.

2 Infra-patellar Bursitis The infra patellar bursa between the upper part of the tuberosity of the tibia and the ligamentum patellæ is small and separated from the synovial membrane of the knee joint by a pad of adipose tissue. When infected there is pain and tenderness over the ligament, and the patient is unable to flex or extend the limb completely. The tibial tuberosity appears enlarged, and there is a fluctuating swelling on either side of the patellar ligament most marked when the knee is actively extended.

3 Sub-crural Bursitis This bursa beneath the quadriceps tendon usually communicates with the joint and shares in its diseases. When cut off from the joint it may be affected independently, and when distended with fluid forms a horse shoe swelling around the patella.

4 Semi-membranosus Bursitis The bursa between the medial head of the gastrocnemius and the semi membranosus tendon is liable to become inflamed, especially in gamekeepers and shepherds. Its apparent predilection for the latter is said to be due to the increased amount of knee flexion necessitated by walking through heather and gorse.

The lesion is accompanied by pain and limitation of movement at the knee joint. The swelling usually enlarges distally in an inter

muscular interval, and becomes elongated or sausage shaped. Such swellings are usually much larger than they appear, since they lie under the deep fascia, they have been mistaken for varicose veins.

The treatment is excision.

Bursitis in the Hip Region

Numerous bursæ have been described in the neighbourhood of the hip joint, but only three are of any practical significance—the bursa overlying the great trochanter, the ischio gluteal, and the psoas bursæ.

1. Trochanteric Bursitis

The trochanteric bursa is one of some size which lies between the tendons of the gluteus maximus and the lateral surface of the great trochanter. In inflammatory conditions, pain and tenderness, usually not very severe, are situated just behind the great trochanter, the tenderness can be elicited by direct palpation over the area, or by rotating the limb. When the bursa is distended the hollow behind the great trochanter is obliterated, and the limb usually rotated laterally to relax the gluteus maximus. Passive movement of the hip joint is not painful, and there is no flexion contracture. Bursitis has to be distinguished from an acute epiphysitis, osteomyelitis of the great trochanter, and from the inflammatory diseases of the hip joint. The bursa is not infrequently the seat of a tuberculous infection.

TREATMENT

In the presence of pus the bursa should be incised and drainage established. The incision is made immediately behind the great trochanter, and care must be taken not to go too far from the trochanter lest the sciatic nerve, which lies close to it when the hip is laterally rotated, be jeopardized.

In non suppurative lesions, rest and physiotherapy are usually sufficient. Tuberculosis of the bursa is most satisfactorily treated by complete ablation.

2 Psoas Bursitis

The large psoas bursa lies between the ilio psoas muscle and the pelvis. Posteriorly and above, it is in relation to the ilio pectineal eminence and below to the capsule of the hip joint. It accompanies the femoral nerve and frequently communicates with the hip joint. When inflamed, pain and tenderness are present in the lateral part of Scarpa's triangle. In the late stage it may suppurate, and fluctuation may then be demonstrated in the same region. The swelling in the triangle may be sufficient, indeed, to obliterate the normal inguinal groove. The bursa is liable to compress the femoral nerve, and pain referred down the limb and to the knee is common, as in hip joint disease. Flexion of the thigh is painful, and the pain increases when the leg is extended. The diagnosis of this condition from hip joint disease, and from psoas abscess, may be extremely difficult.

TREATMENT

The treatment, in acute suppurative conditions, consists of incision and drainage, and in chronic infections of complete excision. The bursa is best reached by a vertical incision lateral to the line of the femoral artery; the fibres of the ilio-psoas muscle are retracted medially to expose the distended sac. It should be borne in mind that the bursa often communicates with the joint cavity, and it may be necessary, therefore, to drain the hip joint also in purulent infections of the bursal sac.

3. Ischio-gluteal Bursitis.

The ischio-gluteal bursa overlies the tuberosity of the ischium. It is often enlarged in those who require to sit for long periods on hard surfaces, hence its popular name of Tailor's, or Weaver's, Bottom. A fluctuating swelling of considerable size projects on the buttock, and may extend down the thigh. It causes great inconvenience in sitting. The sac may contain a number of loose bodies.

The condition has to be differentiated from sciatica, in view of the pain which radiates down the leg. A change of occupation will usually effect a cure, but if the symptoms are severe or persist, the bursa should be excised.

Bursitis of the Shoulder

The various lesions of the bursae in the region of the shoulder are considered in the chapter on Affections of the Shoulder Joint (pp. 673 and 675).

Bursitis of the Elbow

Inflammatory infections of the bursae in the vicinity of the elbow are less common than the other bursal infections. The olecranon bursa and the radio-humeral bursa are occasionally involved.

1. Olecranon Bursitis. The upper olecranon bursa separates the tendon of the triceps muscle from the posterior ligament of the elbow joint, and from the olecranon process, at which point it facilitates the movement of the triceps tendon over the bone. The bursa is usually so small that its presence is not evident. Under the stimulus of repeated trauma, however, it may become distended and appear as a rounded swelling.

The lower olecranon bursa lies between the fascial expansion from the triceps tendon and the subcutaneous triangular area on the dorsum of the ulna. It is large and important. It is frequently the site of pyogenic infection, and of traumatic or trade bursitis, the latter condition being often known as Miner's, or Student's, Elbow. A rounded, fluctuating tumour appears over the olecranon, about an inch and a half by an inch in size. The distended bursa is not tender, nor does it interfere with the movements of the joint, unless it is severely traumatized or infected. Bursitis is sometimes difficult to differentiate from cellulitis of the elbow, or acute arthritis of the elbow joint. Usually, however, there has been a swelling over the olecranon before any question of infection arose.

TREATMENT

The primary attack usually responds to aspiration followed by firm compression by bandages or strapping. If the swelling reappears the sac should be dissected out and completely removed.

2 Tennis Elbow The troublesome and crippling affection of the elbow which is common in those who play certain games such as tennis is considered by some to be due to a radio humeral bursitis, the exact pathology of tennis elbow has not yet been determined however and other causes have been sought to explain it. It masquerades under a variety of names. Thus it is also known as epicondylitis or epicondylalgia. The condition occurs in others than tennis players. In the literature it is reported as occurring among artisans, violin players and dancing masters.

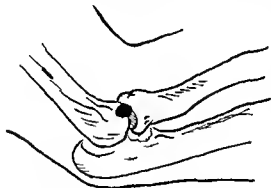


FIG 399.—Radial Bursitis. A possible cause of tennis elbow.

CLINICAL FEATURES

Rarely it has a sudden origin and is accompanied by a definite swelling over the origin of the extensor tendons. More frequently it appears after prolonged and constant exercise which has necessitated continuous flexion or extension of the elbow, and pronation and supination of the forearm. Following

the exercise discomfort sometimes amounting to acute pain is felt in the region of the elbow. Tenderness is present on the lateral or anterior aspect of the lateral epicondyle of the humerus and the patient usually attributes this to a slight strain. The pain is very persistent and gives rise to continuous annoyance. It radiates down the forearm. There is a sense of weakness when attempts are made to perform lifting movements. The condition disappears with rest, but recurs if the original *causative occupation is resumed*.

Examination shows little more than an area of definite tenderness. In the great majority of cases the elbow cannot be fully extended and an attempt to force this position is painful. On active movement with the wrist palmar flexed there is pain at the site of the lesion particularly when the forearm is pronated and the elbow extended.

The many different theories about the pathology of the condition correspond to some extent with the different methods of treatment. Those which have gained the widest acceptance refer the condition to traumatic periostitis or to a tear of the origin of the common extensor with a secondary toxic fibrositis supervening, in a few cases there is an actual bursitis or there may be a hypertrophy of the synovial fringes.

Elmslie emphasizes the importance of toxæmia in cases of tennis

elbow He found the condition most common after the thirty fifth year of age and he states that in his own case his symptoms subsided after the evacuation of a tooth abscess Also in one case in which he performed an exploratory operation he found arthritic changes in the posterior aspect of the joint X ray examination usually offers no solution or there may be some irregularity or haziness of the lateral aspect of the lateral epicondyle

TREATMENT

It is commonly agreed that in the acute cases rest or at any rate abstention from tennis or whatever is the causative factor will bring immediate relief and ultimate cure This is however slow In addition to abstention from games the hand should be placed in a cock up splint to relieve the extensor tendon from tension Various types of physical treatment—short wave therapy radiant heat etc—may be combined with the rest but the effect of this is probably psychical

Mills pointed out that many patients with tennis elbow had been relieved by osteopaths and bone setters He also observed that in patients with tennis elbow when the forearm was fully pronated and the wrist and fingers flexed there was considerable limitation in extension at the elbow By manipulating the elbow into complete extension and keeping up pressure over the medial epicondyle with the hand and forearm in the above position so producing a certain amount of adduction he was able to relieve the symptoms in every case Where the symptoms were of long standing he advocated the use of an anæsthetic In the typical successful case the manipulation is accompanied by an audible click Cyriax uses deep massage before the manipulation and repeats the treatment four times at daily intervals

OPERATIVE TREATMENT

When the condition is thought to be due to bursitis or to periostitis operation may benefit the condition It may be wise to give a preliminary injection of procaine right down to the bone over the tender spot and to observe how far this relieves the condition Often this may succeed in curing the condition The actual operative procedure consists in cutting down to the bone and raising the origin of the common extensor tendon together with the periosteum In exceptional cases an adventitious bursa or a hypertrophied synovial fringe is found and this should be removed

The author believes that the condition is due to tearing of the insertion of the extensor tendons aggravated by the deposition of some toxin in the traumatized part After a reasonable period of conservative treatment consisting of rest strapping of the elbow and diathermy the condition is operated on if symptoms still persist The affected area is exposed after the area of tenderness has been carefully delineated The muscular insertion is erased from the epicondyle and sometimes even a small portion is excised This treatment has been uniformly successful and the author believes this to be due to the subsequent

deposit of scar tissue in the affected region securely reflexing the muscular origin

DUPUYTREN'S CONTRACTION

Dupuytren was the first to describe the characteristic and common affection of the palmar fascia now known as Dupuytren's Contraction. The disease begins insidiously and without apparent cause. It results in the progressive shortening or contraction of the fascia, and has a special predilection for the ulnar side of the hand. The male members of successive generations are often the victims.

PATHOLOGY

At first only the fascia shows any pathological change, ultimately, however, the overlying skin becomes involved. As the finger in consequence becomes more and more acutely flexed, the conformation of the joint surfaces is altered. The earliest manifestation is an isolated nodular thickening seen usually in the line of the flexor tendon of either the ring or little finger or both. Later fresh nodules may appear in the fascia over the other flexor tendons, but the middle and index fingers are rarely affected. The skin on the distal side of the primary nodule is drawn up into a fold and after an interval the finger or fingers become progressively flexed at the metacarpo phalangeal and the proximal inter phalangeal joints. The distal joint is held in rigid extension. Eventually the finger becomes so bent that the tip is permanently in contact with the palm and the power of extension is completely lost. The palmar fascia at this stage can be seen and felt to stand out as a prominent taut cord closely adherent to the overlying skin. The flexor tendons and their sheaths are unchanged, but the joint surfaces of the affected finger may show pressure changes in advanced cases, and the joint capsule is usually contracted to a considerable extent on its flexor aspect. The contracted capsule indeed, may prove a serious obstacle to full extension, even after the fascial contracture has been adequately relieved.

Histology

Meyerding et al. points out that signs of inflammation, proliferation of capillaries and fibroblasts with marked perivascular infiltration affect chiefly the skin, subcutaneous tissue and interstitial connective tissue. The palmar fascia is remarkable, however, for the fact that within its fibres there is evidence of an active proliferation of fibroblasts without other signs of inflammation. The process progresses through the cycle of fibroblastic proliferation and then deposition of collagen fibres which contract and compress the fibroblasts and the final picture of avascular scar tissue results.

Incidence

Dupuytren's contraction is most common in the later decades—a fact borne out by statistics from various workhouses, where it is present

in about 18 to 20 per cent of the male, and in from 2 to 4 per cent of the female inmates. One or both hands may be affected, when bilateral the condition usually starts on one side some time before the second becomes implicated. Any of the fingers may be involved, but the ring finger suffers most, with contraction of the little finger only slightly less frequent.

ETIOLOGY

The cause of the palmar contracture is still unknown. Dupuytren believed that *trauma* was the essential etiological factor, and, in support of this, it is a fact that patients almost invariably ascribe the condition to some injury or hurt, either single or repeated. Usually, however, a considerable time has elapsed between the trauma and the first signs of palmar contracture.

Not infrequently, too, the patients who imagine their trouble originated in injury are industrial workers, to whom the occupational nature of the disability will result in financial gain at the expense of their employers.

The traumatic theory of origin is not very adequately supported by statistics. The error is not by any means confined to workers; indeed, it occurs in those who do little or no manual labour at all. Furthermore, it commonly affects the left hand, even in right handed workmen, or both hands. In view of these incontrovertible facts, it is difficult to believe that trauma is an essential factor.

Guerin believed it to be due to some "*constitutional vice*," such as gout or rheumatism, and his theory had many adherents despite the lack of convincing proof.

There is a striking histological resemblance of the fibroblastic processes in Dupuytren's contraction to other localized fibroplasias such as keloid and fascial desmoid fibroma of the abdominal wall. The concomitant occurrence in some cases of Dupuytren's contracture of thickening and contracture of the plantar fascias and of induration of the penis seem to suggest that there may be something in the theory of a constitutional predisposition or diathesis.

The question of *heredity*, on the other hand, admits of no dispute, the deformity has been constantly noted to affect several generations of a family. The importance of hereditary influences in causing the contracture have not been elaborated.



FIG. 400.—Dupuytren's Contraction

SYMPTOMS

The first sign of the contracture is the appearance of a small hard nodule in the palmar fascia overlying the head of one of the metacarpals. Thereafter the patient notices a progressively increasing flexion contracture, most commonly of the ring finger. Eventually the nodule disappears and is replaced by a narrow cord like band of contracted fascia. Gradually other fingers may show some degree of flexion and the overlying skin becomes puckered and bound down to the contracted fascia. The flexion of the fingers is due to the contraction of the slips or prolongations which pass from the main palmar fascia to the digits, these digital bands do not reach as far as the terminal phalanx, so that the terminal interphalangeal joint remains extended.

Pain is uncommon. Occasionally a dull, aching sensation may be felt in the palm and at times the nodules are distinctly tender.



FIG. 401—Congenital Contraction of the little finger

The metacarpo phalangeal joint is extended whereas in the Dupuytren's type this joint is flexed

DIAGNOSIS

Dupuytren's contraction must be distinguished from—

- (a) Contractions due to injury or infection
- (b) Congenital contractions
- (c) Spastic contractions

The first group can be readily recognized from the history, while in the spastic type the long flexor tendons are the structures principally involved so that when the wrist is fully flexed, to relax the shortened tendons the finger can be extended. In both congenital and spastic contractions too, the metacarpo phalangeal joint may be fully or even hyperextended.

TREATMENT

In the early stages exercises involving hyperextension of the fingers should be prescribed and the patient should be taught to straighten the contracting finger himself at regular intervals. One of the best methods of so doing is to place the fingers, as fully extended as possible and with

their palmar surface down under the buttocks while sitting down on a hard chair. The patient thus sits on the hand.

When the lesion is fully established, such conservative measures are likely to prove unavailing and recourse must be had to operative measures.

Operative Treatment

Only two methods need be considered—

1 Subcutaneous fasciotomy

2 Excision of the affected fascial bands

The ultimate choice of procedure will depend on the nature and the severity of the contracture and on the patient's general condition. The minor operation is useful in mild cases or in those where the main distribution of the contracture is limited to a single finger and the fascial thickening takes the form of a prominent localized band. It is also of value when the age or circumstances of the patient prohibit the more complete procedure.

After the subcutaneous division of the fascial bands, prolonged and assiduous after care is essential if the first improvement is to be maintained. Despite this the contracture is liable to recur since the offending structures have not actually been removed.

The radical operation has the virtue of completely disposing of the affected tissue and it must still be considered the method of choice in severe cases when the patient's other circumstances permit of it.

1 Subcutaneous Fasciotomy The procedure is carried out under a local anæsthetic. A small sharp tenotomy knife is inserted through healthy skin and directed towards the tightened bands which are then divided. The operator's finger should rest on the surface at the site of the division to prevent accidental buttonholing of the skin. A sufficient number of fasciotomies is performed to permit the complete correction of the deformity, and a splint is thereafter applied.

2 Excision of the Affected Fascia This operation is the radical one and the one of choice in cases that permit of it.

Koch has laid stress on certain factors: the correct choice of incision, the use of a bloodless field in operation, complete removal of hopelessly involved skin and wide removal of palmar fascia well beyond the obviously involved area, care in the dissection to protect the digital nerve and blood vessels, the use of a free full thickness graft, careful hæmostasis and careful asepsis. He uses an angled incision down the hypothenar eminence to the head of the fifth metacarpal and then transversely across the palm at the level of the metacarpal heads. Where the finger is affected a straight incision is used on the ulnar side of the digit.

In slighter cases a longitudinal incision may be used over the contracted cord.

The skin flaps are carefully and widely reflected to expose the affected fascia, care being taken not to buttonhole the skin. The tense palmar fascia is divided at the highest possible level, which should be on a line

with the web of the outstretched thumb. It is then separated from its deep attachments by sharp dissection, care being taken to avoid injuring the digital nerve.

The digital nerves lie between the two layers of palmar fascia and are completely surrounded by the fusion of the layers. The nerves must therefore be carefully dissected from it, starting from the normal area proximally.

As the detachment proceeds towards the web of the fingers, the slips of fascia that pass deeply with the transverse metacarpal ligament should be identified and divided.

In the cases where the capsule of the interphalangeal joint is badly contracted excision of the head of the proximal phalanx may be necessary.

If the viability of the skin is in doubt, it is better to excise the suspected portion and complete the defect with a graft, rather than to risk necrosis. Koch advocates a free full thickness graft for this purpose and believes that a more extended use should be made of the method than hitherto.

Post-Operative Treatment

Much depends on the care with which the post operative treatment is carried out particularly in the case of the subcutaneous fasciotomy method.

A splint is worn for seven or eight days. Thereafter in the case of the smaller operation, it is discarded during the day, but worn during the night for a further period of several weeks. The patient should be instructed to extend the affected fingers repeatedly during the daytime, to avoid recontraction. After a month or so the hand should be carefully re-examined to ensure that all the contracted tissue has been severed. Frequently tiny slips will be found to have escaped notice, and will ultimately, if left, spoil the efficacy of the whole operation.

If the excision has been complete, it is unnecessary to retain the splint for longer than a week. The stitches, however, should not be removed for a further week or ten days as the palmar skin is thick and heals slowly. Active movements of the hands and fingers should be begun as soon as the skin is soundly healed.

INJURIES OF MUSCLES

Rupture of Muscle

A muscle may be ruptured as a result of a violent contraction, or by sudden relaxation or elongation when it is in a state of contraction, or by a direct blow sustained when it is actually functioning. It may occur when the muscle is in strong contraction and the group of antagonistic muscles are suddenly and unexpectedly brought into action. The muscles most commonly affected are the short extensors of the toes, the gastrocnemius, the plantaris, the tibialis posterior, the rectus femoris, the biceps humeri, the deltoid, the trapezius, the sterno mastoid, and the abdominal muscles.

The site of the rupture may be either in the muscle belly itself or at the musculo tendinous junction. It may be complete, partial, or only a few fibres may be torn. A hæmatoma forms between the divided ends, and is gradually absorbed, and replaced by scar tissue since the muscle fibres themselves do not regenerate. Afterwards, when the muscle belly is brought into action, there may be a visible prominence above and below the level of the rupture. The contractile function of the muscle is slightly diminished, and, if severe the motion at the associated joints may be limited, and deformity may arise as the fibrous tissue contracts.

At the moment of rupture there is a sudden sharp and stabbing pain, as if from a direct blow, a sensation of something giving way, and immediate disability. Sometimes an audible snap may be heard. The part is swollen and painful on movement, while ecchymosis appears in the skin at the point of rupture. A gap in the muscular continuity may actually be palpable.

TREATMENT

In the incomplete variety, where the line of rupture cannot be palpated, the part should be immobilized in a position which relaxes the affected muscle, the swelling being controlled by strapping, or by a firm bandage. After a few days graduated movements may be allowed, and massage instituted. Faradic stimulation is also useful.

In minor injuries, if treatment is begun promptly, full recovery of function is the rule, except in the case of the posterior spinal muscles where symptoms may persist for a long period. In these cases the delayed recovery may be due to painful adhesions in the scar, and judicious manipulation may therefore prove beneficial.

When the rupture is complete, immediate suture is essential, assuming that the patient is of suitable age and physique. This is especially necessary where the rupture has been at the musculo tendinous junction, as in the gastrocnemius. The post operative treatment entails immobilization until union is firm, followed by physiotherapy of an appropriate type.

INJURIES OF TENDONS

Tendon Rupture

A single tendon may be ruptured by violent muscular contractions, or severed in penetrating wounds. Lacerating wounds and severe contusions may also result in the division of one or more tendons especially where the wounds are situated on the volar and dorsal surfaces of the wrist.

Subcutaneous rupture may result from the sudden over stretching of a muscle, the muscle belly itself remaining intact. The tendon may also be torn away from its point of insertion, with or without an accompanying fragment. The term "*disinsertion*" is given to this type of injury.

Platt has divided tendon ruptures into two main groups

1 The common type, produced by a sudden powerful over stretching of the muscle while in a state of contraction

2 The less common and more insidious form, where the tendon apparently ruptures spontaneously This occurs in certain tendons which occupy a bony groove Here the rupture is determined by friction of the tendon, which gradually leads to attenuation until the tendon ultimately snaps across in response to a comparatively trivial violence It occurs principally in the extensor pollicis longus and in the long head of the biceps brachii

Tendon ruptures may also be classified according to the site of the lesion i.e. at the musculo tendinous junction, in the tendon itself or at its point of insertion

The symptoms and treatment of such lesions are identical with those of rupture of a muscle When the tendon is essential for the preservation of function immediate operation should be undertaken The ends are identified and approximated, the suture being carried out with linen thread It is to be remembered that, in cases of complete division the proximal end quickly retracts and a considerable gap may be present from the moment of injury, especially in the flexor tendons of the fingers

In the case of old injuries, much can be done by a carefully planned reconstructive operation The tendon is carefully dissected out and the scar tissue removed Adjacent tendons should also be freed from the fibrous tissue and gaps, when present, should be remedied by the insertion of a free graft of tendon or fascia lata In spite of the most careful operative technique, however, the results of operation in old tendon injuries are frankly disappointing

A CONSIDERATION OF THE COMMON TENDON RUPTURES

Dis - insertion of the Extensor Tendons of the Fingers (Mallet finger)

The tendon to the extensor digitorum communis is sometimes avulsed by sudden forced flexion of the terminal phalanx such as is caused by a blow on top of the finger at cricket or baseball It seems that it may also happen with very slight violence, as in the case of a housewife making up a bed

The tendon is usually completely detached from its insertion into the distal phalanx,

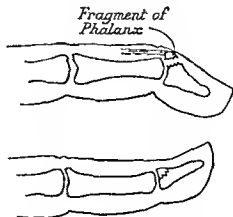


FIG 402 — Avulsion of the Extensor Tendon of the Finger

and it may carry with it a tiny flake of bone. Considerable swelling develops within the first few hours and tends to obscure the fact that the terminal phalanx is unable to move, so that not infrequently the case is seen only at a late stage, when the patient is unable to extend the terminal phalanx. Then the persistent flexion of the phalanx produces the typical mallet finger.

The swelling disappears slowly and the finger is painful for some time. Frequently, in addition to the flexion at the distal interphalangeal joint, the proximal one is fully extended, so that the finger is unsightly, and awkward in use.

TREATMENT

Good results follow prompt conservative treatment. The terminal phalanx should be rigidly immobilized in a plaster-of-Paris case in a position of hyper-extension for at least five weeks. Smillie suggests the preparation of a tube of plaster formed by rolling a piece of cellona bandage about 2 feet long into a tube of such diameter as roughly to fit the finger. The tube is put on dry and the hand placed in water. The patient then presses the tip of the finger backwards with the point of his own thumb. This will secure hyperextension of the terminal joint with full flexion of the middle joint of the finger. It is held thus until the plaster is dry and is worn for three to five weeks. When it is removed, graduated movements are begun, but if there is any tendency for the flexion to recur a further period of fixation should be advised.

This method of treatment is sometimes successful even two or three weeks after the date of the accident. Operation may be necessary in compound cases and in certain old cases which have been overlooked or neglected. An attempt should be made to stitch back the tendon and its insertion into the parent bone after freshening the fractured surfaces. An X-ray should be taken after the accident since if there is no fragment of bone avulsed it sometimes happens that tags of tendon obtrude into the joint and in such cases it may be wise to operate, disentangle the tags, stitch into place if possible, and thereafter immobilise in plaster. In cases where treatment is unsuccessful, the patient may be given the alternative of keeping the finger as it is or of having the terminal joint arthrodesed in a position a little short of full extension.

Injuries of the Biceps.

Most commonly, when the biceps ruptures, the lesion is situated at the attachment of the long head, either in the bicipital groove—an extra-articular rupture—or at its origin from the upper margin of the glenoid cavity—an intra-articular rupture. Rupture of the biceps insertion at the elbow is exceedingly rare, but Platt records a case in which it was avulsed from the tuberosity of the radius.

The tendon of the long head may be ruptured by a sudden overstretching as in lifting a heavy weight, or it may appear to give way gradually and spontaneously after adhesions between the tendon and the shoulder joint have led to its progressive attenuation. Rupture may be preceded by an actual dislocation of the tendon from its groove.

SYMPTOMS

The patient usually feels a sharp pain on the top of his shoulder extending down the anterior portion of the arm to the elbow. Some hear and feel a sharp snap like the crack of a whip, but where a rupture occurs in a tendon already altered by disease the final rupture may occur without the knowledge of the patient. His only complaint may be that of weakness of the arm and a vague feeling of discomfort in the shoulder, attributed to rheumatism. If the rupture occurs in the tendon of the long head and is complete the belly of the muscle will be drawn towards the elbow and will bulge in the lower third of the arm. If it occurs in the lower tendon, the bulging will be seen in the upper third of the arm, and the whole muscle will be drawn up towards the shoulder. When the arm is extended passively the tumour becomes smaller but does not disappear. There may be an extensive ecchymosis in the region of the biceps, especially in lesions of the muscular belly, but this discoloration may be absent in lesions of the tendons. With the arm at rest, the tumour is felt to be soft and mobile and not adherent to either skin or the deep tissues. On flexion of the forearm, especially against resistance the tumour enlarges and hardens. There may be some tenderness on pressure and sometimes pain. The abnormal perceptibility of the tendon of the long biceps, felt under the anterior border of the deltoid, is of prime diagnostic importance, for ordinarily the tendon ceases at this junction and loses itself in increasing spindle belly mass.

DIAGNOSIS

The symptoms which accompany the disability as well as the type of onset and the findings on examination are valuable. These are detected easily by inspection of the shoulder and arm (shape, deformity, abnormal tumour, hollow, and ecchymosis), by palpation which confirms the site, shape, volume, elasticity and hardness of the tumour, by abnormal perceptibility of the tendon, and by examination of the function which is more or less impaired. The classical signs of this rupture are Heuter's sign (pain in the shoulder when the supinated forearm is flexed), Pagenstecher's sign (subluxation of the humeral head upwards and medially), and Cruveilhier's sign (elevation of the humeral head). Although noted the author believes these signs to be more of theoretical interest than of practical value.

TREATMENT

Occasionally good functional results are obtained by conservative measures, but often, even in the case of partial rupture, loss of function is very marked. Operation is therefore advisable. An incision is made in the arm where one expects to find the lesion. If the long head is ruptured at its attachment to the lip of the glenoid or near its upper end, the ruptured tendon may be sutured to the tendon of the short head or to the coracoid process. Where the tendon is too short for this, it may be possible to insert it to the floor of the sulcus intertubercularis, after roughening the floor of the latter. This is done by

splitting the tendon and fixing it firmly through holes made in the back of the sulcus. Where there is some loss of tendon at the lower part it may be necessary to resort to a transplant of fascia lata. If the rupture occurs in the muscle proper in addition to suturing the muscle one should overlap a large fascial transplant for reinforcement. For the repair of a rupture of the lower end two methods have been employed—fixation of the tendon on the radius with a nail or if this is not possible suture of the tendon to the neighbouring soft tissues. In old standing cases especially in old people operation is rarely worth while.

Rupture of the Extensor Pollicis Longus

Many cases of rupture of the long extensor of the thumb have been recorded in surgical literature. The injury occurs either as an isolated lesion or in association with a fracture of the lower end of the radius. The isolated type is seen in kettle drum players, and is said to be preceded by a mild tenosynovitis. It was known to German military surgeons by the name of Kettle Drummers Palsy. When associated with fracture the tendon rupture usually takes place some weeks after the bone is injured. The fracture apparently leads to some distortion or unevenness of the tendon groove so that the tendon becomes adherent and thereafter weakened through gradual attrition. Finally it ruptures.

The rupture is recognized through the inability to extend the terminal phalanx of the thumb against resistance and by the absence of the subcutaneous bow string normally formed by the tendon when the thumb is fully extended. The loss of function may also be demonstrated by stimulating the muscle belly by the faradic current. There is little or no dropping of the terminal phalanx as the distal end of the tendon is usually adherent to the lower end of the radial groove.

TREATMENT

Operation offers the only chance of a reasonable functional result. In recent injuries end to end suture is usually possible but the ruptured tendon should not be replaced in its groove until the latter has been smoothed. Its oblique course should be preserved and if necessary a pulley constructed from a free fascial graft.

In old standing cases where there is a considerable gap between the ends direct suture may be attempted first but if it prove impracticable either a free tendon graft should be employed to bridge the defect or the tendon be transplanted into one of the tendons of the short thumb muscles.

AFTER TREATMENT

The thumb should be supported in a plaster case in full extension for three weeks. Thereafter gradual mobilization is begun due precautions being taken to prevent over stretching.

Rupture of the Tendo Calcaneus

This is an accident of middle life and may result from various types of trauma. It is commonly found in tennis or badminton players

and in many cases it occurs when the individual is taking a step backwards

The rupture is usually complete the tendon giving way through its narrowest part about $1\frac{1}{2}$ inches above its insertion. The line of separation is transverse and may be clean like an incised wound or ragged from the projecting bundles of tendon fibres. The sheath may or may not remain intact and the proximal end of the tendon rapidly retracts. The interior of the sheath rapidly fills with blood and its walls become œdematous. The plantaris usually escapes damage.

Incomplete ruptures are rare except at the musculo tendinous junction. French writers have however described a rupture *en deux temps* where an incomplete division is converted into a complete one by a second injury some weeks later.

CLINICAL PICTURE

At the moment of rupture the patient experiences a sharp pain as if he had sustained a blow on the heel. There is immediate and considerable disability and in a short time swelling and tenderness appear. The patient is unable to walk without experiencing severe pain.

In untreated cases the sheath may become adherent to the retracted ends of the tendon and so act as a feeble bond of union enabling a certain amount of muscular contraction to occur. The calf muscles remain shortened and plantar flexion is permanently diminished.

DIAGNOSIS

Where the rupture has occurred only twenty four to forty eight hours before it is seen the examination may be rendered difficult by the marked œdema which tends to disguise the gap between the separated ends. The following points may be said to establish the diagnosis.

- 1 The presence of a gap into which the finger can be introduced and which is increased by dorsiflexing the foot.

- 2 Unduly high level of the prominence caused by the bellies of the calf muscles.

- 3 An abnormal range of passive dorsiflexion compared with that on the uninjured side. This sign naturally is absent in cases of partial separation.

- 4 Inability to perform or marked limitation of plantar flexion. A certain degree of plantar flexion may be obtained by the action of the peroneus longus the tibialis posterior and the long flexors of the toes but this feeble effort cannot be compared with the normal movement which follows active contraction of the calf muscles.

TREATMENT

A recent complete rupture should be repaired as soon as possible by operation. With the ankle plantar flexed and the knee flexed to relax the calf to its utmost the ends can usually be approximated without undue tension. The suture should be carried out with kangaroo tendon unless the tear has been a ragged one when the sutures may cut out. Under these circumstances a living suture of fascia lata should

be employed. Wherever practicable the sheath should also be carefully restored.

After operation the leg should be immobilized in plaster of Paris with the foot in full plantar flexion and the knee flexed. Three weeks later the foot is gently brought to the right angled position, the plaster re-applied, and the patient allowed to walk. In six weeks the plaster is removed entirely, and the patient allowed to get about in a shoe with an elevated heel. Massage, faradism and exercises in walking may all be usefully employed in the convalescent period.

Operative treatment should also be recommended in the old neglected ruptures associated with instability of the leg. Several methods may then be employed to repair the defect. The suture line may be reinforced, for example, by a strong fascial strip, or by the plantaris tendon which can be left attached to the calcaneus and divided high in the calf. It may even be necessary to turn down a flap from the proximal end in order to obtain apposition. A free tendon graft may also be employed to bridge the defect. In these cases Platt recommends the transplantation of the peroneus longus and the tibialis posterior into the calcaneus at the site of the tendon insertion in order to strengthen the bond of union.

Rupture of the Plantaris Tendon

A diagnosis of a ruptured plantaris is frequently made but universal doubt is cast on its occurrence as an actual entity. It is more than likely that the condition which goes by this name is rather an incomplete rupture of the tendo calcaneus, or of some muscular fibres in the calf. The disability is slight, and responds well to conservative treatment, which consists of the application of adhesive strapping to the leg, the patient being encouraged to walk. In some cases a slight elevation of the heel of the foot will assist in the disappearance of symptoms.

Rupture of the Rectus Femoris

The tendon of the rectus femoris may be torn across during a powerful contraction of the quadriceps. The lesion is therefore similar in nature, and occurs as an alternative, to fracture of the patella from muscular violence. The fibres are usually avulsed from the upper border and the anterior surface of the patella, but a slender strip of the deeper part of the tendon may remain intact. If the quadriceps pouch is torn at the same time a hemarthrosis accompanies the rupture.

The patient is usually past middle age, and the clinical features are typical of tendon ruptures in general. In spite of the integrity of the vastus medialis and lateralis, extension of the knee is quite impossible, and there is an obvious gap between the two ends of the divided tendon.

Repair of the rupture by operation should always be attempted, except in aged patients or those of a bad physique. After suture the bond of union should be strong enough in three weeks to allow cautious and graduated movement of the knee joint.

When operation is contra indicated, the knee should be kept fully extended, preferably on a posterior splint

Rupture of the Ligamentum Patellæ

This is the least common of the various injuries of the extensor mechanism of the knee. In nature and etiology it is similar to rupture of the quadriceps and fracture of the patella. The upward recession of the patella, the absence of the ligament on palpation, and the loss of power of extension are the obvious diagnostic signs.

In an early case repair by suture is usually practicable. In long standing and neglected ruptures, where the ligament has been gradually replaced by an attenuated band of fibrous tissue, a new ligament should be constructed. A long strip of fascia lata is passed through a drill hole in the tibial tubercle. The two free ends are sutured, under tension, to each other and also to the remains of the ligamentous tissue at the apex of the patella. The knee is then immobilized in extension for three weeks at the end of which time active movements of the quadriceps muscle and cautious mobilization of the knee joint may be carefully undertaken.

Dislocations of Tendons

The Peroneal Tendons

Dislocation of the peroneal tendons, upwards and forwards from their normal position behind the lateral malleolus, is by no means rare, and, unless efficiently treated at the beginning, is apt to recur. The dislocation may affect one or both tendons.

The condition occurs usually in older children, and may escape notice for some time, frequently a definite snap is felt at the time of dislocation and this may attract attention to the lesion.

The dislocation may be either traumatic or the result of a congenital malformation of the groove in which the tendons lie. In paralytic talipes calcaneo valgus a similar displacement is occasionally seen. The displacement usually occurs when the foot is dorsiflexed and abducted.

The signs include local swelling and ecchymosis. The function of the foot is not seriously impaired, though the lateral ligament of the ankle joint is usually torn. The patient feels as if something had given way in the foot, and the tendon or tendons are then found to be over the malleolus or in front of the malleolus.

A recurrent dislocation, though often causing no disability, is not infrequently evidenced by a slight lump.

TREATMENT

In recent cases the tendons should be reduced, and kept in place by adhesive plaster applied over a felt pad laid over and behind the malleolus. If the ankle is then kept at rest with the foot inverted for four weeks a return of the displacement is unlikely.

In recurrent cases of dislocation there appears to be a choice of

two methods of treatment. In that commonly used by the author the peroneal groove behind and below the malleolus is deepened by means of a sliding graft of bone from the malleolus slid downwards. By means of an osteotome the lateral aspect of the malleolus is separated from the main bone in a vertical direction and then slid downwards about $\frac{1}{2}$ inch or more if necessary and fixed by means of a screw nail. Excellent functional results follow this operation.

Jones suggested an operation in which he used a strip of the tendo-calcaneus to thread through the fibula. The tendo calcaneus is exposed and a tendon strip 2 $\frac{1}{2}$ inches in length and about $\frac{1}{2}$ inch in width on the lateral aspect of the tendon is freed from above downwards and left attached at its calcanean insertion. The peroneal tendons are firmly retracted. A hole is drilled transversely through the fibula $\frac{1}{2}$ inch above the tip of the malleolus and the tendon slip is passed from behind forwards through the drill hole looped and sutured on itself. This operation prevents the re-dislocation of the peroneal tendon therefore making a capable substitute for a retinaculum.

Trigger Finger

Trigger Finger is a condition in which some obstacle to full voluntary flexion or extension of the finger is present and the movement can be completed only by assistance. When thus passively moved past the position in which it is arrested the finger jerks into the desired position with a faint audible snap.

The phenomenon is due to a stenosing tendo vaginitis of the flexor tendons of the finger. When the band is opened and shut the affected finger shows a slight range of movement but remains in a position of flexion. When the digit is passively extended slight resistance is encountered until a certain point is reached after which the movement is free.

It usually affects the middle finger of the right hand particularly in women. the ring finger and thumb are also occasionally affected.

Croft believes the lesion is at the level of the metacarpo phalangeal joint where the tendon sheath is normally slightly narrowed by contact of the accessory volar ligament. The obstruction may also be caused by a circumscribed thickening of the actual tendon or by a definite thickening in the sheath wall.

If rest in a splint for some weeks followed by massage proves ineffective in relieving the condition the tendon sheath may be explored. Any thickening of the tendon should be excised or when the sheath itself is the site of stenosis it should be incised longitudinally and the opening left unsutured.

Stenosing Tendo vaginitis at the Radial Styloid

This is an affection of the tendon sheaths of the long abductor and the short extensor of the thumb characterized by fibrosis of the sheath and narrowing of the intrathecal lumen.

It occurs at the point where these tendons pass under the superficial dorsal carpal ligament in the fibro osseous canal immediately overlying the lower end of the radius. The tendons in this situation are exposed to continual friction, and, since they lie superficially close to the skin they are also very liable to external trauma

ETIOLOGY AND PATHOLOGY

The cause and nature of the condition are imperfectly understood. It appears that the excessive use of the involved tendon is the most likely explanation since it occurs almost exclusively amongst workers who use their thumb a great deal. In some instances however it apparently follows a single direct blow. In both cases the effect is to induce an increased friction between the two tendons and the rounded distal end of the radius. An œdema of the tendon sheath is thus produced and this results in a vicious circle since it further increases the friction. Ultimately fibrosis leads to an actual stenosis of the sheath at this point.

Kocher was the first to name the condition Stenosing Fibro Tendo Vaginitis. He noted the fibrous thickening of the middle layers of the sheath and looked upon the condition as a hypertrophy of a similar nature to trigger finger.

The X ray examination frequently fails to show any change in the underlying bone although occasionally especially in old standing cases there may be a deposit of lime salts at a point on the radius which corresponds to the site of the stenosis of the sheath.

CLINICAL FEATURES

The patient invariably complains of severe pain at the wrist usually localized in the region of the radial styloid, the pain may radiate into the hand and up the forearm. The onset has been gradual usually without any precipitating trauma. The pain becomes so severe in the course of weeks or months that the wrist is completely disabled. It may be neuralgic in character and is very severe at night. It is also aggravated by abduction and extension of the thumb or by pressure over the radial styloid.

Examination usually demonstrates a visible swelling in the region of the styloid which is extremely tender to pressure. Occasionally a cartilaginous like thickening can be felt under the skin while at times the periosteum of the underlying radius is also thickened. There is never any redness infiltration, or rise in local temperature, while crepitus on movement is never elicited.

TREATMENT

Two methods only are likely to be of any avail—prolonged immobilization or operative intervention.

Conservative measures do not yield encouraging results. Schneider encases the wrist and the abducted and extended thumb in a plaster of

Paris case According to Schneider if the case is retained in place for four to six weeks it is attended by a complete remission of symptoms in seven out of ten cases. Other means of immobilization may be employed but in all cases it must be sufficiently prolonged to permit complete resolution of the pathological changes which have taken place in the sheath.

When the fibrous stenosis has become too advanced to respond to simple immobilization surgical interference provides a simple and effective remedy. Under a local anæsthetic a linear incision about 1½ inches long is made through the skin and subcutaneous tissue over the distal end of the radius. A small branch of the radial nerve is retracted and an incision made through the carpal ligament immediately over the tendon sheath. The thickened sheath is divided longitudinally for a distance of about 1 inch. The skin is then closed and the wound bandaged but not immobilized. Active movement is begun within a few days and full restoration of function may be expected within two or three weeks.

ACUTE INFECTIONS OF THE HAND

Infections of the hand and fingers may take many forms and accurate diagnosis of the various types is essential to good and proper treatment. The acute infections are due to the introduction of pyogenic organisms. When pus is present the term *whitlow* is used to describe it. The chronic lesions are associated with syphilis and tuberculosis and will not be discussed here.

The organisms may be introduced through a small trivial wound such as a pin prick, a puncture by a splinter of wood, or through a fissure. The various types of whitlow gradually merge into one another and sometimes more than one form is present. The onset is usually abrupt and the local manifestations of inflammation—heat, redness, swelling and pain—are quickly apparent round the site of entry of the organisms. The pain may attain great severity and is worse if the arm is dependent or if the part is squeezed or knocked against anything. The patient is usually unable to sleep and the general condition deteriorates rapidly.

Ishel, to whom I pay tribute for an excellent monograph on the subject, emphasizes that the pathological anatomy is the foundation of the whole problem of acute infections of the hand and classifies them in a way that is easy to understand for each has its own clinical features and its own particular incision.

Classification (Ishel—modified)

1. *Whitlows*

(A) **SUPERFICIAL WHITLOWS**—in one of the layers of the skin

- i Subcuticular whitlows
- ii Peri ungual whitlow (paronychia)
- iii Sub ungual whitlow

- iv Carbuncle (anthracoid or furuncle of the finger)
- v *Acute spreading infections*
- vi Gangrenous whitlow
- vii Erysipeloid

(B) DEEP WHITLOWS—subcutaneous

- (a) Infections of the subcutaneous cellular tissue—cellulitis
 - i Whitlow of the pulp
 - ii Whitlow of the second phalanx
 - iii Whitlow of the first phalanx—basal segment
- (b) Infections of the tendon sheaths—tenosynovitis

Digital tenosynovitis of the second, third and fourth fingers (the others being abscesses of the hand rather than whitlows of the finger)

2 *Complications of Whitlows*

- i Osteomyelitis of the phalanx
- ii Arthritis

3 *Abscesses of the Hand*

(A) SUPERFICIAL

- i Superficial phlyctenoids (septic corns)
- ii Superficial carbuncles—mainly on the dorsum of the hand

(B) DEEP (subaponeurotic)

- i Infections of the tendon sheaths, radial and ulnar
- ii Infections of the cellular spaces—thenar, hypothenar, middle palmar spaces (pre tendinous, retro tendinous and commissural) and dorsal

(A) Superficial Whitlows

1 *The Subcuticular Infection*

This condition also known as a purulent blister usually results from pricking the finger. An abscess forms in the skin of the palm though it also occurs on the dorsal aspect. It raises the epidermis from the dermis over a varying area which may include the greater part of the finger. Frequently a subcuticular collection of pus co exists with an infection of the subcutaneous area, the two communicating through a small sinus in the dermis. This "hour glass" or "collar stud" abscess is found particularly at the webs of the fingers, and especially in men who resume arduous manual labour after a period of idleness. In the collar stud type the superficial pocket is small, the finger is swollen and tender, and pain does not cease with pus formation, unlike the ordinary superficial collection.

TREATMENT

The separated epithelium is completely removed with scissors and the exposed dermis carefully examined for the presence of a small sinus leading to the subcutaneous space. No anaesthesia is necessary for this small operation. The thorough removal of the detached epithelium is essential, otherwise the persistence of undermined edges favours the

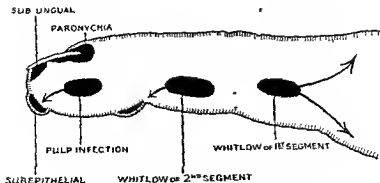


FIG 403—The Varieties of Whitlow

The arrows show direction of spread

development of further infection. A simple absorbent dressing is applied.

When a small sinus is found leading below the dermis it may be that the removal of the raised epidermis is enough to drain the deep abscess. But if there is still pain present in two days a further opening is carried out under general anaesthesia.

ii. Paronychia

The troublesome form of subcuticular infection which affects the nail-folds is known as paronychia. The infection may be introduced through a "hang nail," or by the separation and elevation of the eponychium when the nails are manicured. Two varieties of this type have to be distinguished from the anatomical point of view according to whether or not there is pus under the nail. The peri ungual type is a simple septic blister, while in the sub ungual type the nail is attacked by the underlying pus. The infection may start on one side of the nail, but it tends to spread towards the base and the opposite side and is therefore known as the "run around."

The infection therefore may be an acute localized one, giving rise to a small abscess in the subepithelial tissue at the side of the nail. If this is incised, immediate recovery takes place, but, when neglected, the pus spreads along the side of the nail and back to the base, becoming secondarily a typical "run around."

The more frequent type is that associated with chronic infection along the edge of a "hang nail." For a few days pus may exude from the inflamed area about the nail-edge. Then a certain amount of swelling and redness may be observed, but with little or no pain. In some cases the pus may burrow deeply towards the bone for the proximal edge of the nail lies in contact with the phalanx. The swelling usually however extends round the base of the nail until eventually the opposite side is reached. At the end of two or three weeks drops of pus may be expressed from under various parts of the eponychium. A few weeks later the entire nail may be detached along its base, but in spite of the improved drainage there is still a chronic discharge from the original nail sulcus and a fungus like mass of granulation tissue growing

from the nail bed. Although the base of the nail is raised entirely from its bed, the distal exposed portion remains firmly attached to the matrix.

TREATMENT

The pus is evacuated through a longitudinal incision along the lateral side of the nail. It extends back to the base as far as the sulcus and passes well to the lateral side of the nail to avoid damaging the nail bed or the overhanging cuticle. The eponychium is pushed back with a sponge and the point of a sharp scissors inserted under the detached edge of the nail which is cut off along with any portion of the nail root which has been undermined by the pus. The flap of cuticle reflected by the incision is now kept elevated by inserting under it a small strip of gauze saturated with vaseline. Hot moist dressings are then applied for two days at the end of which time vaseline gauze dressings are employed.

When more than half of the nail base has become involved in the swelling and redness a second incision is made on the other side of the nail and after reflecting a flap of the entire eponychium the nail fold is packed as before. The entire nail root will often be undermined in such cases and if so it is completely removed, the distal adherent portion of the nail being left undisturbed. The end of the finger then remains protected by the adherent part of the nail and that is most important. When the nail is completely removed the patient suffers much pain from the dressing or even a light touch on the nail bed.

(ul) Sub ungual Whitlow

This type follows a perforation of the nail or a partial detachment of the nail. The pus collects as a small abscess between the nail and its bed either at the tip of the finger or at its lateral aspect. It may spread and invade the pulp or towards the bone and produce an osteo-

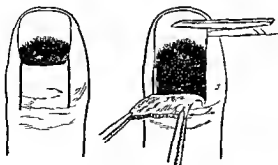


FIG. 404.—The Method of removal of the detached part of the Nail in Paronychia

myelitis. Violent pain prevents sleep and there is a sensation of tightness and throbbing. Palpation with a small instrument reveals a sub ungual part of maximum tenderness. When the pain is thus localized operation is indicated. An incision is made parallel to the nail edge and at the point of maximum tenderness. A triangular piece

of nail is excised in order to expose completely the abscess cavity. Healing occurs quickly and usually the nail grows without deformity.

(iv) Carbuncular Infections

Carbuncles may develop on the hand as elsewhere. They affect the hair bearing portions on the dorsum particularly the dorsum of the proximal phalanx and the ulnar aspect of the back of the hand. The staphylococcus is the usual infecting organism.

The carbuncle may develop either in the hair follicle and its associated sebaceous gland or in the convoluted sweat glands. The infection then spreads downwards into the subjacent fat and extends laterally until it eventually fills up the loose space under the skin. From there it ascends into other glands in the neighbourhood and from these numerous sources the infection extends to the surface straining as it were through a sieve. The central part of the lesion becomes necrotic and pus and debris are extruded on the surface. The drainage is inadequate however and the process still tends to extend round the periphery.

Clinically the lesion presents a central zone of necrosis. In its immediate vicinity the skin is perforated by a series of pus exuding sinuses. Beyond this there is a blueish zone which is undermined by pus which has not yet penetrated the skin. Surrounding the entire lesion there is an area of induration which indicates the inflammatory nature of the process.

TREATMENT

The carbuncle should be freely laid open by cruciate incision which extends well beyond the indurated edge into normal tissue. The four flaps thus marked out are reflected until healthy tissue is exposed all round the periphery. Any free sloughs are removed but curetting is undesirable and harmful. Hot moist gauze is now packed under each flap to ensure drainage. The packing is removed at the end of twenty-four hours and the flap allowed to fall back into position.

Good results are reported by the local injection of Bacteriophage antivirus. Four injections of 2 c.c. give excellent results and operation has been given up by some surgeons in favour of this method.

(v) Acute Spreading Infections

This is more than a lymphangitis since the skin is involved as well as the subcutaneous cellular tissue. The type of the disease varies. It may be a fleeting lymphangitis or it may be accompanied by abscess formation. The typical case develops areas of necrosis leading to loss of skin. It is very common in doctors and nurses and often a very serious and may be fatal condition.

The lumen of the lymphatics becomes occluded by bacteria and fibrinous clots and the endothelial lining is destroyed. Around the vessel there is a collection of leucocytes. The commonest infecting organism is the streptococcus and the bacteria are confined to the actual lumen of the lymphatics.

SIGNS AND SYMPTOMS

A minute wound or pin prick, surrounded by redness and swelling, may or may not be visible. The incubation period is very short, the patient usually showing signs of an infection of the gravest type after a very few hours. In other cases the infection appears to follow a mild course and then quite suddenly the infection flares up to an alarming extent. If the terminal phalanx is the primary site the whole finger may be swollen and red, and there may be red streaks along the dorsum of the hand and on the forearm. These streaks represent the dilated and inflamed lymphatic tubules, and are tender and easily felt on light palpation with the fingers as tightly stretched threads.

The lymphatics of the hand pass almost invariably by the shortest route to the dorsum and hence dorsal oedema and redness are constantly found in palmar infections. The back of the hand is pink in colour and pits readily on pressure.

When the primary focus is situated in the little or ring fingers or at the ulnar margin of the hand, infection spreads by the lymphatic tubules along the ulnar margin of the forearm to the epitrochlear glands, which become enlarged, painful and tender. Some of these lymphatics, however, pass directly to the humeral group of the axillary glands, without communicating with the epitrochlear glands.

When the primary focus is in the thumb or index finger infection travels by the lymphatics along the radial side of the forearm. Some of these vessels incline medially across the front of the forearm, to pass with the lymphatics of the ulnar side to the epitrochlear glands or to the humeral group of the axillary glands. The majority pass along with the cephalic vein on the lateral side of the arm, to the delto-pectoral interval, where they terminate in one of three ways—by draining into either the infra-clavicular group of the axillary glands, the delto-pectoral glands or very rarely, the supra-clavicular glands.

It will be evident, therefore, that lymphangitis from an infective focus in the thumb, index, or middle finger is potentially much more serious than that from a focus in the ring or little finger, since infection may spread directly to the infra-clavicular or even the supra-clavicular glands, rendering systemic involvement much more probable.

The hand and arm are rosy red in colour with purplish hues in places. The redness is accompanied by an infiltration of the tissues most prominent on the dorsal aspect but also involving the medial borders. Often livid patches can be seen which alter in colour hourly into green, brown, and later black. The tissues are markedly infiltrated and the skin has a granular and irregular surface. Palpation of the whole area is almost painless. The swelling limits movement. There is no lymphadenitis in most cases though it is occasionally present and may go on to suppuration.

In the fulminating cases death occurs in a few days following on a most extraordinary impairment of the general condition. Within

two days the body is wasted, the skin dry, the eyes hollow, the lips open and dry, showing the teeth and gums and producing a most impressive and unforgettable facies

In the more fortunate patients a less rapid course is present and the symptoms are less overwhelming. Gangrenous patches may occur in the skin and late pulmonary infections are to be expected. There is a third group where the local lesions are less extensive and where the gangrenous process is localized.

The organism is usually the hæmolytic streptococcus alone or with other organisms, but the non hæmolytic type and others are found. Such infections do not confine themselves to those of poor physique and poor general health. Rather the opposite in fact, since they often occur in those of robust health. The important factor seems to be the extraordinary virulence of the micro organism.

TREATMENT

Vigorous treatment should be started at once since any case may go on to the most acute fulminating type.

Medical As in all serious infections large, warm, moist and sterile dressings are applied, the arm splinted, and the patient's strength maintained by all available means and sulphonamides given in full doses.

Surgical In this condition there is no pus but only a cloudy serous fluid teeming with organisms and incisions are not likely to be helpful, at any rate in the early stages. In fact intervention may be, and usually is, dangerous. Koch believes that the lesions must have no surgical interference, as long as there is no localization they must be treated on medical lines only. On the other hand when the gangrenous process is limited, when the sloughs appear, and when abscesses develop, one must without delay excise the gangrenous patches and open and drain the abscesses.

Prevention As soon as a prick is received the wound should be made to bleed freely and an antiseptic—either tincture of iodine or dettol—freely applied. A sterile dressing should then be kept on for 24 hours. If, however, the prick shows signs of inflammation the question of treatment is difficult and it is certainly unlikely that incision or excision will be of any avail. It is equally certain that the patient should at once have full and continued doses of sulphonamide.

(11) Gangrenous Whitlow.

Iselin points out that often a finger infection apparently following a normal course suddenly becomes gangrenous over a more or less extensive area. This he says is due to an arterial thrombosis and not to local anæsthesia, tourniquet or antiseptic dressings hitherto believed to have been important in the production. The gangrene is noticed when the dressing is changed. The skin is cyanotic, cold and insensitive. It may occur in a simple whitlow or in a case of acute diffuse suppuration. There is no pain or general disturbance but the finger is in-

evitably lost Treatment is, of course, disarticulation of the finger through healthy tissue as soon as possible

(vii) Erysipeloid

This curiously enough occurs in the catering trades—fishmonger, greengrocers cooks, etc. It is seen as a curious red and painful swelling usually at the base of the finger. There is no pus. It progresses slowly and may spread from one finger to another.

It appears two to fourteen days after an injury, usually a scratch. There is a sensation of tightness itching and heat. Round the wound is a dark red raised zone. The pain is often severe and is accentuated by changes in temperature. There is no rise of temperature nor are there any general symptoms, but in some cases there is glandular enlargement. The condition lasts two to three weeks and local recurrences are common. The cause is the bacillus of swine fever (*B. erysipelatis suis*).

Treatment is entirely conservative and consists of warm moist dressings and later the part is painted with tincture of iodine. X ray therapy and sulphonamides are also recommended.

(B) Deep Whitlows

(a) Infections of the Subcutaneous Cellular Tissue

These infections develop in the cellular tissue of the palmar aspect of the fingers. The palmar creases on the fingers demarcate three segments each of which corresponds to a phalanx. The distal pulp space is the commonest type of whitlow and is unique because it is not a loose space since the fibrous bands tack down the skin to the periosteum and penetrate the bone. The middle space is localized by fibrous partitions above and below, and from the bone by the deep tendons covered by a strong fibrous arch. The proximal space is separated from the middle by this fibrous partition, but communicates with the palm along the lateral aspects of the base of the finger and therefore can easily infect the cellular planes of the web of the finger. The cellular tissue of the proximal and middle spaces is much looser and less resistant than that of the pulp.

(i) The Pulp Space Infection

The pulp space abscess also known as a felon is one of the commonest infections of the distal phalanx. There is usually a history of a pin prick, but not infrequently no preceding injury can be discovered. On the second or third day after infection the tissue is oedematous and infiltrated with yellow serum around a small central area of necrosis seldom larger than a cherry stone. There is severe pain in the distal phalanx, at first pricking in character, but rapidly becoming throbbing so that the patient is unable to sleep or even to rest. The distal portion of the finger becomes red, swollen, and tender, and the tenderness is situated for the most part over the area of involvement. In the later stages pus forms, and with the tissue destruction this sensitiveness disappears. The top of the finger is at first tense from oedema, but

this tenseness is soon replaced by induration and loss of its normal resilience—a cardinal sign indicative of pus. Later there is a fluctuating boggy mass unless as is more usual the pus has perforated to the surface before this stage. In the pulp of the distal phalanx the connective tissue framework is so arranged as to form a terminal closed sac while the strands which unite the skin to the periosteum form an easy pathway for infecting organisms. It is not unusual therefore to have the periosteum and the bone secondarily infected. If pus develops in this closed space it is held under considerable tension and has no means of free egress. As the pressure rises the vessels which supply the distal part of the phalanx and which lie one on each side of the space are obliterated, necrosis of the bone following as a direct consequence. The branches which supply the epiphysis are derived before the main arteries enter the space and hence the necrosis is limited to the diaphysis. The pus may spread to the surface under the dermis producing a collar stud whitlow—usually at the tip on the palmar aspect. It may spread laterally and gain the lateral edges of the nail fold. Lastly it may spread deeply and infect the bone. The pulp space infection of the thumb may in addition spread to the thenar space or along the long flexor tendon sheath.

TREATMENT

The treatment of felon consists of immediate incision into the infected area as soon as pus has formed. Great care should be taken however to avoid incising a finger in which there is a lymphangitis rather than a localized collection of pus. There is no necessity to wait until fluctuation has actually begun, as by that time the patient will have suffered unnecessary pain, there will be considerable destruction of tissue and a severe grade of toxæmia. The time of election is when the œdema of the pulp is giving place to hardness and induration. Kanavel says that when there is present a painful tender distal phalanx and excessive œdema limited to that phalanx an incision should be made.

The incision should be situated on the lateral aspect of the phalanx so that after healing the tactile portion of the finger will be left free from scars. The pulp space extends from the tip of the digit to the level of the epiphyseal line of the terminal phalanx—that is a quarter of an inch distal to the last interphalangeal crease. The incision therefore should not extend further proximally than this. The incision should be long enough to open the pocket freely. It is unwise to make a circular flap incision round the end of the finger and if the single lateral incision appears to be insufficient a second should be made on the opposite side.

If the phalanx is bare and exposed in the abscess cavity it should be removed. If only one part of its circumference is exposed it should not

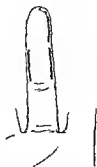


FIG. 105.—The incisions for incision of the Pulp and of the Second segment.

he interfered with as it frequently heals without giving rise to any trouble. If the joint is found to be seriously involved amputation is generally advisable.

THE AFTER TREATMENT

The after treatment consists of the local application of hot moist dressings until the acuteness of the inflammation subsides. The hand should also be elevated to lessen the throbbing pain. When the acute symptoms have subsided the finger is dressed by gauze thoroughly smeared with Balsam of Peru which permits the free escape of pus and the painless removal of the dressings.

(ii) Whitlow of the Second Phalangeal Space

This is a special type described by Isehn. The pus is circumscribed to the palmar aspect of the second phalanx and is usually more fluid and contains fewer sloughs than that of whitlow of the pulp. It may spread towards the skin as a collar stud abscess and only exceptionally into the adjacent spaces or into the tendon sheath. The finger is red, oedematous, flexed and rigid. Tenderness is present throughout the length of the second phalanx. There is no pain over the tendon sheath in the palm and in front of the proximal phalanx—an important diagnostic point. It may be difficult to differentiate this whitlow from a tendon sheath infection but in the latter there is pain along the line of the sheath with a maximal point of tenderness at the proximal end—i.e. over the palmar cul de sac of the sheath.

TREATMENT

Under anaesthesia and in a bloodless field the pus cavity is located by a probe after the skin of the hister is removed. A lateral incision is made towards the collection of pus far enough back on the lateral aspect so as not to endanger the digital vessels. A strip of rubber dam may be inserted and even pulled through a second incision on the opposite side. There is no danger of pressure ulceration of the sheath which is well protected at this level.

(iii) Whitlow of the First Phalangeal Space

Infection in this area is uncommon and is usually caused by direct infection of the space through a puncture or incised wound. It develops in two to three days, soon involves the lateral aspects of the finger and then spreads to the web of the finger on one side only.

The clinical signs are those of a whitlow with pain predominating at the base of the digit. In asymmetrical swelling is observed at the base with involvement of the web. The neighbouring finger is separated from the infected one. The redness and swelling is principally on the palmar aspect but spreads towards the dorsum. Lymphangitis is often present. The point of maximum tenderness reveals the site of the pus and it is to be noted that this tenderness is not over the upper cul de sac of the tendon sheath in front of the metacarpophalangeal joint as in a sheath infection. Although the finger is often flexed it can be extended easily. This condition has to be distinguished from an infection of

the web itself and this is done by noting that the web infection is accompanied by a symmetrical swelling and oedema that involve the bases of the neighbouring fingers

Treatment Iselin recommends a three branched incision the digital branch opening the lateral aspect of the finger along the line of union of the dorsal and palmar skin and carried up to the web while the



Fig. 406.—The Incision for an infection of the proximal Segment

second and third branches split the web from before backwards from the base of the digital incision. A counter incision on the other side of the finger is unnecessary. No drains are required in this wide exposure but the wound is lightly packed with iodoform gauze. In three to four days the packing is omitted and the fingers allowed to approximate. When healed the scar is concealed in the web.

Infection of the Synovial Sheath—Tenosynovitis

The tendon sheath may be involved either by lymphatic extension or by direct continuity from a subcutaneous whitlow. Direct inoculation unless precipitated by careless incisions is rare but the sheath may occasionally be infected from a subcutaneous abscess in the lumbrical canal.

Infection through the lymphatics may follow a needle prick commonly in the distal or middle phalanx and is usually streptococcal in origin.

Klapp has shown that at an early stage the pus is localized to one or two segments of the sheath. complete invasion is secondary and takes place in an irregular manner. The pus collects in front of the joint as the sheath shows a dilatation in front of each of the finger joints separated by two narrower portions. The narrowing is produced by the constriction of the two pulleys or aponeurotic bands which enclose the tendons in front of the first and second phalanges. The tendon is restricted in this aponeurotic tunnel at these two areas and there is no room for pus. But in the inferior the middle and in the palmar dilatations each opposite a joint there is a space where the pus can and does collect. The swelling and implication of the tendon sheath produces a further narrowing and produces what Iselin calls a functional partitioning of the synovial cavity.

Extension from one sheath to another follows strictly the anatomical

relationships and occurs usually through a lumbrical space or through a fascial space. The ulnar bursa may be involved from the little finger and the infection then commonly extends to the radial bursa and to the sheath of the flexor pollicis longus. The pus may extend from the synovial sheath into the thenar space either by rupture of the sheath

directly into the space or via the lumbrical spaces on either side of the proximal phalanx. Less often the proximal interphalangeal joint may be affected. The synovial sheath of the thumb tends to rupture into the forearm less commonly the thenar space may be implicated.

When the tendon sheath is affected the finger becomes red, painful and swollen, the swelling spreading rapidly to the dorsum of the hand. Sheath involvement is indicated by the absence of voluntary movement, the finger becomes rigid and contracted and attempts at passive extension induce great pain. Local tenderness is marked and is confined to the anatomical limits of the sheath; it is usually most evident over the proximal end, at the metacarpo-phalangeal articulations.

The four cardinal symptoms and signs of tenosynovitis are

1 Excessive tenderness, limited to the disposition of the sheath.

2 Symmetrical enlargement of the whole finger.

3 Excruciating pain on extending the finger, this is most marked opposite the proximal end of the sheath.

4 A persistent attitude of flexion of the finger due to distension of the sheath. It is inconstant and disappears when spontaneous rupture has taken place and when the distension has been relieved by a small incision.

Often the only sign is pain on pressure over the upper cul-de-sac of the sheath, in front of the head of the metacarpal bone.

Two clinical types have to be distinguished.

1 Where the infection generally staphylococcal is a local one such as that which commonly follows lacerated wounds. This type begins slowly and there is time for plastic adhesions to form and limit the infection. There is little general reaction but the local evidences are well marked.

2 Where the injury is slight of the nature of a pin prick or an insignificant cut. The infection is usually streptococcal and is carried to the sheath by a lymphatic vessel. The pain is severe and in a few hours the finger is swollen, red and exquisitely tender. There are early evidences of toxæmia. Plastic adhesions have not time to form.

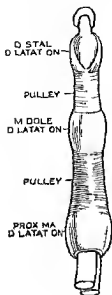


FIG. 407.—Diagram of the Digital Tendon Sheath showing the important dilatations (After Iselin.)

and the infection accordingly spreads rapidly through the entire system of communicating sheaths. This type is apt to be associated with early rupture of the sheath and extension into the connective tissue spaces. In neglected cases, there may be a spread into the palm or forearm or a joint may become infected and undergo complete disorganization. The infection may spread directly into the forearm in the case of the thumb and little finger, but only after a preceding invasion of the palm in the case of the other fingers. In the forearm a diffuse cellulitis or a localized deep abscess forms under those circumstances.

Tenosynovitis of the Little Finger

The flexor tendou sheath of the little finger communicates with the ulnar bursa in the majority of cases, in 80 per cent of cases the ulnar bursa communicates with the radial bursa, so while infection may remain localized to the finger, it usually extends to other areas and particularly to the ulnar bursa, the radial bursa and the fascial spaces of the hand and forearm.

In the fulminating type infection of the ulnar bursa is rapid. This complication is marked by the development of oedema especially on the dorsum of the hand. Although concavity is still present there is a fullness in the palm and also immediately above the annular ligament. The most conspicuous sign, however, is the spread of the exquisite tenderness to the new area involved, the point of maximal tenderness being known as Kanavel's sign. The tenderness is most marked at a point just proximal to where the distal flexion crease of the palm abuts on the hypothenar eminence.

When the infection spreads still further to involve the radial bursa, there is swelling and tenderness in the thenar eminence, and along the sheath of the flexor pollicis longus.

When the infection has spread to the forearm from a ruptured sheath, the pus tracks along the connective tissue, or rather the intermuscular spaces. It first passes between the flexor digitorum profundus and the pronator quadratus to the space, known as Parona's space, between the flexor muscles and the interosseous membrane, at or about the middle of this area it passes more superficially, and towards the ulnar side, along the ulnar artery and nerve. The forearm becomes the seat of a brawny induration, but fluctuation need not be expected, since the abscess is deeply situated. When a definite ulnar or radial bursitis has lasted forty eight hours, an extension should be assumed, and appropriate incisions made.

When there is no free communication between the tendon sheath of the digital flexor and the ulnar bursa, the pus may rupture into the lumbrical or the palmar spaces. The web between the ring and little fingers is swollen and red and the ulnar side of the adjacent ring finger is often similarly implicated. A collection of pus in the middle palmar space is accompanied by a slight bulging of the palm which replaces the normal concavity.

Tenosynovitis of the Index, Middle, and Ring Fingers

Infection of the tendon sheaths of these fingers has the same features as that of the little finger but the pathways of extension are somewhat more limited. The most common spread is to the lumbrical space on either side of the proximal phalanx. From there it may spread to the dorsum of the hand via the web to the tendon sheath of the adjacent finger or to one of the palmar spaces—the middle in the case of the ring and middle fingers and the thenar in the case of the index finger.

Tenosynovitis of the Thumb

Tenosynovitis of the thumb usually precedes an infection of the radial bursa and has similar features to the other types of thecal whitlow. The thumb is held in a position of semiflexion and is uniformly enlarged. The patient may be able to flex the digit slightly but under no circumstances can he be persuaded to extend it actively and passive extension is attended with extreme pain. Exquisite tenderness is elicited by pressure on the volar aspect of the proximal phalanx and the metacarpo phalangeal joint.

The spread to the radial bursa is usually rapid occasionally also the radial is infected from the ulnar bursa and very rarely from the thenar space. In all cases pain swelling and tenderness are present over the limits of the bursa. The thenar eminence looks fuller than normal but the swelling here is mild in comparison with the ballooning that accompanies a thenar space infection.

In addition to the pain in the thumb the index finger may also be slightly sensitive in radial bursitis.

Should the infection spread to the ulnar bursa the symptoms and signs of ulnar bursitis supervene and actually predominate. It has to be emphasized that in such a spread there is no gross swelling of the palm.

In late and neglected cases the radial bursa ruptures into the forearm the rupture is preceded by the development of a swelling immediately above the transverse carpal ligament from there the pus passes deep to the flexor tendons into the forearm.

TREATMENT OF TENOSYNOVITIS

A careful and detailed clinical examination should be carried out before the patient has been anesthetized and before any iodine has been applied to the skin since accurate diagnosis is essential. An anæsthetic is necessary in all cases and the use of a tourniquet essential if satisfactory drainage is to be secured.

Iselin opens only the superior cul de sac of the sheath since he points out that is where pus collects and where the tendon is in greatest danger. The operation is done under anesthesia and with a tourniquet and four incisions are made. The two palmar ones are made just proximal to the web on each side of the affected finger and run vertically upwards for 2 cm. The cul de sac is opened on each side

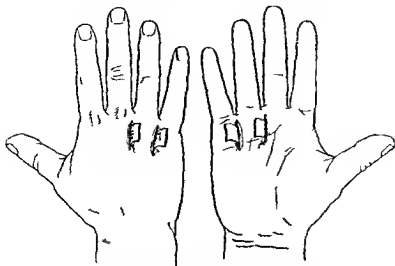


FIG 408 —Isehn's method of opening an infected Digital Sheath The Drains are inserted through the proximal dilatation

and a pair of forceps pushed back to raise the skin on the dorsum where an incision is made over the points. The forceps is pushed through, and opened to grasp a strip of rubber dam which is pulled through to the palm. Dry dressings are applied and changed but seldom. Pain may persist for two to three days.

If in three to four days this drainage is unsatisfactory the dorsal incision is lengthened and the pulley divided on one side. This incision leaves the vessels and nerves intact in front of the wound.

Other surgeons make an incision more distally however, so in the middle and proximal phalanges the incision should be on the antero lateral aspect, just in front of the digital vessels and nerves. The resulting scar is thus removed from pressure and the tendon is prevented from starting forwards or prolapsing through the wound. The interphalangeal creases should be avoided unless they appear to act as constricting bands to the distal portions of the fingers. Once the pus has been discovered, an incision long enough to secure thorough drainage is required. The tendon sheath should therefore be carefully examined and, if distended and full of fluid, or if pus can be seen escaping from it through a small hole, it should be split up along its entire length, the overlying tissues

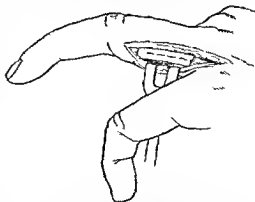


FIG 409 —If drainage of the proximal dilatation is not enough the first Pulley for the Tendon is exposed and divided along one side (After Isehn)

including the skin being divided accordingly. If the tendon is found in a sloughing condition it should be removed, but it should in all cases be given the benefit of any doubt as to its vitality.

2. The Complications of Whitlow

The infection may extend from its primary site to infect neighbouring and important areas. Thus it may involve the joint, giving rise to a suppurative arthritis, it may implicate the bone, and produce an osteomyelitis, or it may and not infrequently does extend to the fascial spaces in the palm of the hand.

(i) Suppurative Arthritis

This is most commonly due to extension from a thecal whitlow, the proximal interphalangeal joint being the most frequently affected.

The pathology is similar to that of suppurative arthritis of any other joint. The usual constitutional disturbance is present, and locally the joint is red, hot, swollen and painful while its function is seriously interfered with. The joint tends to assume an attitude of slight flexion. An abscess may form on the dorsal or the dorsal lateral aspect of the joint and eventually sinuses may supervene.

TREATMENT

The best and most satisfactory treatment when the distal interphalangeal joint has become involved is immediate disarticulation through the joint.

When the proximal interphalangeal joint is infected, amputation through the metacarpophalangeal joint offers the best chance, although if there is no tenosynovitis and the joint is only partially involved, excision may be carried out. Excision, however, is not attended with a good functional result and it is therefore rarely indicated.

(ii) Osteomyelitis and Bone Necrosis

The distal phalanx is most commonly affected usually from a subcutaneous whitlow. A radiographic examination may show the presence of a sequestrum and a probe inserted through the sinus will encounter bare bone.

TREATMENT

The sequestrum or the necrosed bone, should be removed. Amputation should not be carried out at the same time, as in many cases the periosteum will form new bone to make good the defect. In such a case an excellently functioning finger may be secured.

(iii) Extension to the Fascial Spaces of the Palm

Extension to the palm may complicate the subcutaneous or other types of whitlow, signs of infection may then arise in the thenar or middle palmar space, or in the radial or ulnar bursa.

These will be described later.

3 Abscesses of the Hand

(1) Infection of the Synovial Sheaths of the Hand

These sheaths or bursæ enclose the flexor tendons in the carpal canal and in the palm and are two in number—the radial and the ulnar. The radial encloses the long flexors of the thumb and becomes continuous with the digital sheath at the base of the thumb. The ulnar bursa forms a sheath for the two layers of the flexors of the fingers and communicates directly with the digital sheath of the little finger. The sheaths extend to about 25 millimetres above the radial styloid.

Infection is generally through a punctured or incised wound in the neighbourhood of the tendon. Less often the infection may be due to an extension of a subcutaneous whitlow of the first or fifth finger or a whitlow of the cellular spaces.

PATHOLOGY

In the early cases the pus completely fills the radial bursa but in the ulnar bursa it only occupies the deeper retro-tendinous part where the communication with the digital sheath of the little finger is situated.

When inflamed the external aspect of the sheath is oedematous and congested. The interior is dull thickened and in places shows yellow plaques. The infection may pass from one bursa to the other generally along the pre-existing anatomical communication. Extensions into the cellular spaces are frequent as is also extension into the forearm which of course is a serious complication. When the latter occurs the pus escapes from either bursa into the cleavage plane that lies behind the posterior aspect of the sheath and in front of the pronator quadratus, a space known as the space of Parona. Further spread may then take place upwards into the forearm along the plane between the two groups of flexor muscles.

There are two main types of infection of the bursæ—

(1) The purely synovial form in which the diagnosis based on classical signs is easy, the treatment simple and the prognosis excellent with modern technique.

(2) The diffuse form in which diagnosis is difficult of which the

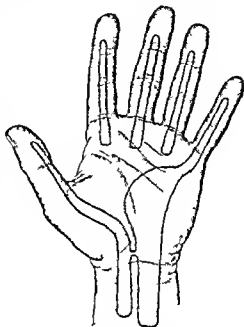


FIG. 410.—Infection of the Hand. The synovial compartments of the palm.

treatment calls for multiple interventions, and in which the outlook is much more uncertain

In the first type the pus is still within the synovial sheath and the signs are definite. In the diffuse tenosynovitis pus has already spread to one or other of the spaces to be described, the signs are misleading and often incomplete

CLINICAL FEATURES

Pain appears on the day following infection, first in the finger and then in the hand and finally in the wrist. It increases rapidly, prevents sleep and causes a high temperature. On inspection the hand is enormous swollen on its palmar, but especially on its dorsal aspect. The swelling and redness spread to involve the front of the forearm. The fingers are semi flexed.

1 Simple Infections of the Bursæ

The flexed finger and the shooting pain typical of a tenosynovitis, are present. Any attempt to straighten the finger increases the pain, which is felt most severely in the infected finger, so that in an infection of the radial bursa the thumb only is completely rigid and inextensible, while the other fingers can be extended. When the ulnar bursa is infected the fifth finger is stiff and tender.

2 Diffuse Synovitis

The classical signs of tenosynovitis are no longer present. The difficulty lies in the recognition of a synovial infection underlying the

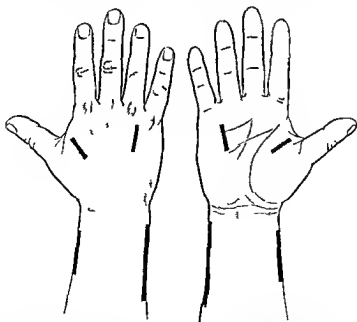


FIG. 411.—Incisions used for draining an extensive tenosynovitis. Through and through Drains are inserted through the fourth interosseous space, the thenar space and the Forearm.

more serious collections in the cellular spaces and diagnosis cannot usually be made with certainty until the hand has been explored

When the infection remains localized in the sheath the prognosis is good although functional impairment of the affected finger usually results. In diffuse infections however the condition of the hand after healing is usually very bad. The wrist is ankylosed the fingers may be stiff and rigid in the typical attitude of interosseous paralysis

TREATMENT

Iselin points out that uncomplicated synovial whitlows and diffuse ones require different operative technique. The uncomplicated teno-synovitis requires forearm incisions over the superior cul de sac. For an ulnar bursa infection the ulnar incision is enough but for a radial bursa infection or an infection of both bursae the ulnar incision is com-

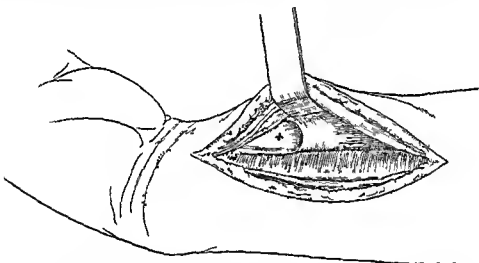


FIG. 412.—The incision to expose the Tendon Sheath in the Forearm. The flexor carpi ulnaris is retracted after stripping it from the Ulna and the synovial Sheath exposed. It may have burst or may require opening at + (After Iselin)

pleted and supplemented by a short radial incision to permit introduction of through and through drainage

For a diffuse synovitis additional incisions in the hand are required. Incisions into the finger are useless. The hand incisions enable us to insert transfexion drains through the interosseous space between the fourth and fifth metacarpals when the ulnar bursa is involved and through the web of the thumb in infection of the radial bursa. If there should also be an extension into the superficial palmar space it must be evacuated by a low median incision. In making the lower forearm incision on the ulnar side it is made over the easily palpable border of the ulna for a distance of about 3 or 4 inches. The aponeuroses are incised immediately in front of the border of the ulna along the line of the interspace that lies between the ulna and the flexor carpi ulnaris tendon. The wound is enlarged in an upward direction by

detaching the lower fibres of that muscle from their insertion into the bone. The flexor carpi ulnaris is then retracted and the deeper aponeurosis which is best marked in the lower part where it forms almost an accessory covering to the deeper portion of the ulnar bursa is incised. The pronator quadratus is then exposed and recognized by the transverse direction of its fibres and the pearly lustre of the tendinous strands of its insertion into the ulna. It is absolutely necessary to get down to the pronator quadratus.

The ulnar nerve and vessels are neither seen nor in danger because they are displaced forward and protected by the retractor. The finger is thrust under the tendons relaxed by flexion of the wrist to ascertain the extent of upward spread and the cutaneous incision is extended as far as may be necessary.

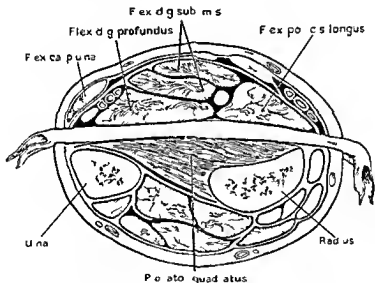


FIG. 413.—A Section of the Forearm above the Wrist showing the Method of draining Parona's Space.

When the pus is still within the sheath no pus is discovered when the pronator quadratus is exposed and the tendons lifted. The synovial cul-de-sac must then be exposed and opened. This is easily done because the cul-de-sac bulges when pressure is applied to the palmar pouch and is then easily visible. Care must be taken to make the opening sufficiently large to furnish adequate drainage. Drainage is best ensured by a rubber strip.

The Radial Incision. In making this incision care must be taken not to carry it down further than 3 cm. above the radial styloid so as to avoid the radial artery and the abductor pollicis longus. The superficial aponeurosis is incised along the anterior border of the brachioradialis. The incision should not be made too far forward because that would endanger the radial artery. In this situation we seek to expose

the pronator quadratus which is still covered by the deep aponeurosis. The external border of the flexor longus pollicis is exposed just below its last fibres of origin from the radius. This border is freed and retracted inwards with the radial artery. The pus has generally become diffused in the retro-tendinous space but in some cases it may be necessary to evacuate it by an incision. A radial incision is never sufficient alone though an ulnar one may be since it furnishes dependent drainage.

When the tenosynovitis has become diffuse palmar incisions are required. The ulnar palmar incision 2 cm long is made in the fourth interosseous space reaching down to 1 cm from the web. Forceps are passed through the space from front to back and the projection of its points cut down on to make a shorter dorsal incision. A through and through drain is introduced.

The thenar incision is made into the thick of the commissure of the thumb mid way between the interval border of the thenar eminence and the base of the thumb. An incision is made on the dorsal surface of the first interosseous space and a through and through drain inserted to evacuate the palmar and any dorsal collection.

POST OPERATIVE TREATMENT

Usually cure ensues after the sheaths and the extensions have been opened. The hand is immobilized in the position of function on a plaster slab or a wire splint. The temperature usually falls and reaches normal in four or five days. The dressings are changed but seldom in the case in which the temperature comes down satisfactorily but otherwise the dressing is removed at once for inspection. Absolute immobilization of the hand in an elevated position to keep the forearm incisions dependent is essential to ensure a successful result. The drains are removed about the fifth or seventh day and the dressings and splints reapplied and immobilization continued for a few days longer.

(11) Infection of the Palmar Cellular Spaces

Six cellular spaces of the hand are described by Iselin. In the central palmar region there are three—the superficial pre-tendinous palmar space, the deep retro-tendinous palmar space and the commissural or web spaces. There are also the thenar space in the thenar eminence, the phyto-thenar space in the hypo-thenar eminence in front and the dorsal space on the back of the hand.

(1) *The central superficial pre-tendinous palmar space* lies in the palm of the hand immediately underneath the palmar aponeurosis and is limited behind by the tendons and the vessels of the superficial palmar arch. The lateral boundary lies along the line of the second metacarpal while the medial boundary lies along the fourth inter-metacarpal space. It communicates with the forearm, the first web space of the finger and with the retro-tendinous space.

(2) *The deep central palmar space.* This lies behind the flexor tendons and in front of the deep palmar the so called interosseous aponeurosis. It communicates with the fingers through the lumbrical canals with the thenar space and with the forearm behind the tendon sheaths.

(3) *The commisural spaces* are three in number and lie in the webs of the fingers and are about the size of a cherry stone.

(4) *The thenar space* lies in front of the transverse head of the adductor pollicis behind the thenar or inter muscular aponeurosis attached to the third metacarpal.

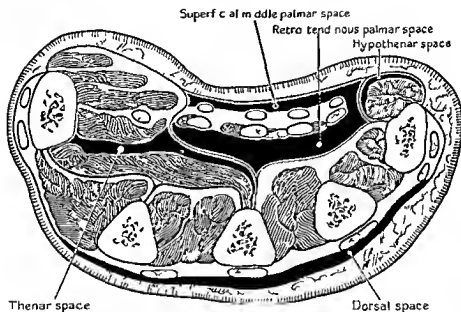


FIG. 414. The cellular spaces of the hand shown in a cross-section.

(5) *The hypo-thenar space* is limited on all sides by the hypo thenar aponeurosis which commences on the external border of the fifth metacarpal and terminates on the ulnar border of the same metacarpal.

(6) *The dorsal space* is limited in front by the extensor tendons united together by a thin fibrous layer and behind by the superficial dorsal aponeurosis and the skin.

From the anatomical point of view therefore there are six varieties of cellular infection of the hand corresponding each to one of the spaces above described. The distinction between tendon sheath infections already described and those of the cellular spaces is that sheath infections are much more serious while infections of the cellular spaces are more frequent and may spread to the sheath if the collection is not recognized early and opened up before it has had time to spread to involve these neighbouring structures.

1 Infection of the Thenar Space.

This space is anatomically well defined and therefore its infection should produce characteristic cubical effects. The pus is located in the palm, anterior to the transverse head of the adductor pollicis. It spreads towards the web and from there may reach the dorsal aspect. The thenar region is markedly swollen both on the palmar and dorsal aspects but this swelling ceases abruptly at the adductor crease of the thumb and the remainder of the palm is flat, supple and painless. Palpation elicits intense pain on pressure over the thenar eminence and over the web which is red and so swollen that the thumb is held abducted by the swelling. For the drainage of this collection Kanavel prefers an incision over the web of the thumb, the space being approached thereafter by inserting closed artery forceps in the direction of the space.



2 Infection of the Hypo-thenar Space

The pus is localized between the hypo-thenar muscles and their aponeurosis and completely fills the space. Intense pain is experienced, while the area is red, swollen and extremely tender. The notable feature is the restriction of the symptoms to the hypothenar eminence. The space is incised antero laterally and drained by a strip of rubber and usually heals quickly, in less than a week.

FIG. 413.—Incisions for draining the palmar spaces. The palmar incisions along the Lumbricals give access to the deep central palmar space while the thenar space is approached through the Thumb Web.

3. Infection of the Retro-tendinous Central Palmar Space

This is not a common infection and usually results from a rupture of the digital tenosynovitis which has burst at the superior cul-de sac. The amount of pus is never very large, usually not more than about 1 drachm. It usually produces a paralysis of the interossei, which paralysis may remain for some time. Often there are trophic changes in the fingers as a result of involvement of the nerves and vessels in their palmar course.

CLINICAL FEATURES

Following on a tenosynovitis which has been opened the temperature and swelling do not subside, or may reappear after having temporarily improved. The pain becomes dull and localized in the palm. The swelling is visible on inspection and is associated with redness of the median part of the palm, particularly towards the webs of the fingers and on the dorsum of the hand. Flexion deformity of the fingers is not marked but active movements are painful. The palm is painful on pressure and this may produce some exudation of pus from the

drainage incision of the tenosynovitis. The hand is characteristic in appearance in that the first phalanx is extended while the second and third are flexed, but not to any marked extent.

Isehn suggests that the operative methods are two in number (1) Drainage of the collection by incisions avoiding injury to the sheaths, and (2) amputation of the finger in which the infection originated. The latter is suggested particularly in cases of tenosynovitis where the original operation has been by a median incision which certainly destroys the function of the finger. He also resects the head of the metacarpal since it acts as a plug and blocks from below the infected spaces. Where the condition has not been a sequel to a tenosynovitis Kanavel makes an incision through the inferior portion of the interdigital space along the lumbrical muscle. This incision can be prolonged upwards for $\frac{1}{2}$ cm into the palm. A pair of closed forceps should be passed up under the tendons into the retrotendinous space and then opened to evacuate the pus. A strip of rubber in this incision gives good drainage.

4 Infection of the Superficial Pre-tendinous Central Palmar Space

The term 'subcutaneous' given to this space is erroneous since the collection is subaponeurotic and not subcutaneous. Infection may come from infected blisters or a whitlow, or from cuts and pricks. The pus lies under the palmar aponeurosis and the tendons in their sheath are pressed backwards to form the posterior wall of the infected space. There is usually only a few cubic centimetres of pus. The collection may spread towards the skin of the palm and produce a collar stud abscess or it may spread to the web or to the thenar space.

CLINICAL FEATURES

There is severe pain and high temperature. The centre of the palm of the hand is markedly swollen with well marked lateral limitations. There may be swelling in front of the wrist with redness and oedema spreading up the forearm. Active movements of the fingers and wrist are restricted but passive movements are normal.

The treatment consists in incision of the palm in the mid line. The vessels and nerves lie deep to the pus so are out of danger. The edges of the skin and the aponeurotic wound should be excised to prevent their tendency to close. Spread in any direction is treated by counter incision.

Infection of the Finger Web

This is the most common of these infections. Pain is localized to the finger web and is severe. The two fingers on either side of the affected web are separated and cannot be approximated. The web itself is swollen and red both in front and behind. The swelling is symmetrical, differing from a whitlow of the first phalanx. The hollow of the palm and its surroundings remain quite normal. Finger movements though restricted, are still possible and painless.

TREATMENT

An incision 2 cm. in length is made on the palmar aspect of the web to evacuate the collection. A dorsal counter incision is added and a strip of rubber pulled through. Whenever the infection appears to be serious the web of the finger may be completely split. This gives little trouble later as the cut edges tend to fall together.

Dorsal Cellulitis

In an infection of the dorsal space the pus is subcutaneous the vessels, nerves and tendons being displaced forward against the deeper planes. The pus may spread over the whole extent of the dorsal aspect but usually remains confined to the hand and does not extend to the wrist.

CLINICAL FEATURES

The pain is moderate but the temperature rises quickly. Inspection reveals considerable swelling and redness of the entire dorsum of the hand. Oedema involves the roots of the fingers and spreads up to the forearm which is streaked by lines of inflamed lymphatics.

Diagnosis is not always easy because the pus may be masked by the extensive oedema of the back of the hand.

TREATMENT

Suppuration may be obvious otherwise the base of the inter-digital space in which pus is suspected is incised. The pouch is then explored with curved forceps and counter incisions made and drains inserted from one to the other.

Some Considerations in the General Treatment of Hand Infections

The patient should be confined to bed and the usual treatment of toxæmia carried out. A light nourishing diet is given and an attempt made to eliminate the toxins by way of the bowel, the kidneys and the skin. Blaud fluids are given liberally by the mouth. In most cases sulphonamides are given in full doses.

Surgical treatment must be carried out as early as possible so when ever the infection is localized the appropriate incisions are made. It is important however to wait until the diagnosis of the location of the pus is certain. Incisions are made under perfect anaesthesia and always with the aid of a tourniquet. The best form of drain is thin sheet rubber. Drains are not used as a rule in the finger but only in the hand. They should be removed as soon as the inflammatory signs of oedema and lymphangitis have disappeared. Iselin points out that dressings are used only to protect the wound from external contamination and are in no way therapeutic. They absorb the secretions and to a certain extent splint the affected part. He suggests a little gauze to separate the cotton wool from the wound, absorbent cotton wool to absorb the secretions, impermeable cotton wool to prevent the filtering

through of secretions, and a bandage to fix the dressing. The antiseptics he advocates are petrol and Dakin's solution—the former to clean the blood and dissolve the fat, and the latter when there is no fat to dissolve and because it is an excellent antiseptic. It is not used once the wound is clean.

Every infection goes through three stages and an appropriate dressing is recommended for each one.

1 *The Inflammatory Period* This is the time when there is oedema, lymphangitis and general signs. Hot and moist dressings are used. The swabs and the absorbent wool are well moistened in warm water and a layer of non absorbent cotton wool placed on top to maintain moisture and heat and yet allow aeration. Impermeable materials are not used since they give rise to maceration and swelling of the skin. The hand is immobilized and kept slightly elevated. The moist dressings are not renewed but the outer non absorbent cotton wool is frequently changed and the inner layers moistened with warm sterile water.

2 *The Elimination Period* The general signs have improved, suppuration has set in and the folds of the skin reappear as the oedema disappears. The warm and moist dressings are now discarded. The wound is bathed with Dakin's solution and a swab of gauze moistened with Dakin's solution applied and covered with absorbent and non absorbent cotton wool. This dressing need only be changed every two days unless soaked through with discharge.

3 *The Period of Repair* The wound is clean and granulating though of course still suppurating. The epidermis is beginning to grow. The wound is covered with a dressing that will not disturb the process of repair. Antiseptic treatment now ceases and a dressing that will not adhere is applied. Iselin suggests balsam of Peru or Collargol ointment and only changes the dressing twice weekly. Exuberant granulations are turned with the silver nitrate stick. Hand baths are only used when there is no open wound since they are then useful in relieving pain and in localizing the pus. When there is an open wound baths are too prone to produce re infection and they also produce maceration of the skin and swelling, and tend to close incisions. From the outset the hand is immobilized in the position of function with either plaster of Paris or a light metal splint. Mobilization begins only when the healing process is complete and the movements are of an active nature only. No forcible passive movements are allowed.

Amputation is sometimes called for, and the following may be held to indicate the removal of the part.

- 1 Sloughing of the tendons
- 2 Suppurative arthritis
- 3 Stiffness of the finger—either in the flexed or the extended position
- 4 Osteomyelitis—acute or chronic
- 5 Gangrene
- 6 Painful scars

SNAPPING HIP

An audible sound or click may be heard or felt during certain movements of the hip joint. It may have a variety of explanations some of which are intra articular while others are due to factors outside the joint.

The rare intra articular type occurs in children and is due to slight voluntary displacement of the head of the femur over the upper and posterior border of the acetabulum so that the thighs are sharply flexed and adducted. The displacement eventually becomes a habit and is best prevented by firm bandaging to prevent hip flexion.

The more common extra articular type is analogous to luxation of the peroneal tendon at the ankle. The snap is heard and felt when the knee is flexed and the hip rotated medially. At times a tight band may be seen to slip backwards and forwards over the great trochanter. This form occurs both in adults and children and is apparently due to friction between the anterior border of the gluteus maximus and the trochanter or between a fascial band and the bony prominence. It is also encountered in cases of arthritis or in effusion into the bursa between the gluteus maximus and the femur. An X ray film should be taken to exclude the presence of osteomata or of osteochondritis. The snapping may become habitual and a source of considerable discomfort to highly strung nervous people.

The writer recalls a case where following an osteotomy for a flexed and adducted tuberculous hip a snapping hip developed on the healthy side. The abductor on the normal side was apparently displaced medially to the great trochanter so that the fascial band snapped backwards and forwards over it.

If operative treatment becomes necessary division of the offending band or tendon or surgical resection of the prominence of the trochanter and a fibrous mass arising from the tensor opposite the trochanter gives an excellent result. If an osteoma or exostosis is present it is of course removed.

When the tensor fascia latæ is at fault the author makes three vertical incisions separated by three eighths of an inch in the tensor fascia and divides them below so as to form two long strips attached to the muscle above. The two tails are then laced through an antero-posterior perforation in the trochanter one entering from behind and one from the front. They are sutured together and so fix the important factor in the causation of the snap.

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